XX. *Reduction and Discussion of the Deviations of the Compass observed on board of all the Iron-built Ships, and a selection of the Wood-built Steam-ships in Her Majesty's Navy, and the Iron Steam-ship 'Great Eastern'; being a Report to the Hydrographer of the Admiralty. By* Frederick J. Evans, *Esq., Master R.N., Superintendent of the Compass Department of Her Majesty's Navy. Communicated by Captain* Washington, *R.N., F.R.S., by command of the Lords Commissioners of the Admiralty.*

Received May 5,—Read June 21, 1860.

Sir, London, April 18, 1860.

In compliance with the general instructions I received from you on my appointment, to observe carefully the working of the Mariner's Compass in the ships of Her Majesty's Navy, and especially in iron vessels, both for the security of their navigation and the aid of science, I now beg leave to submit for your consideration the following Report treating on these points, and in which is embodied an analysis of the magnetic character of all the iron-built ships in Her Majesty's Navy, as also of several of the wood-built steam-ships.

In directing attention to this analysis, as given in a series of Tables, it is necessary to advert to the observations on which it is based, as resulting from a general system pursued in the Royal Navy.

On the foundation of the Compass Department in 1843, a periodical examination of the disturbance caused by the iron on the compass in each ship,—or the deviation of the compass as it is now familiarly known to seamen,—was directed to be made by the Lords Commissioners of the Admiralty; the records of this examination are duly preserved in the Hydrographic Office, and have been employed in this investigation.

The compass specially selected at this period (and since retained with a few modifications) for the navigation of Her Majesty's ships, and with which all observations for the deviation are made, and to which the steering or binnacle compasses of the ship are referred, is well known as the "Admiralty Standard*." This compass is solidly fixed in the middle line of the ship, within the limits of the quarter-deck; generally at a distance from the stern varying from one-fifth to one-tenth of the vessel's length, and raised sufficiently high from the deck to secure bearings of terrestrial objects above the gunwales or bulwarks, which ensures a height varying from about 4 feet 6 inches to 6 feet 6 inches; an essential condition of its arrangement being that it is kept as free from the immediate vicinity of iron as the nature and equipment of the vessel will permit.

The details of all the essential parts of the Admiralty Standard compass, including

* A brief description of this compass, and the chief points in its construction, is appended.

the cards and needles, are uniform throughout; the intensities of the latter being remarkably so, and also permanent over long periods of time: the observations made with this compass are therefore strictly comparable, and it will be understood that the results given in this Report, except when specified to the contrary, and the inferences arising therefrom, must be considered as applying to a compass in the various details of position and structure just described.

The analysis of the deviations of the compass in iron-built vessels, embraces forty-two ships of the Royal Navy; and including the wood-built screw and paddle-wheel steam-vessels, as also the deviations observed in various parts of the steam ship 'Great Eastern' during her experimental trip to Portland in the autumn of 1859, has involved a computation of nearly two hundred and fifty Tables.

In order to render the analysis complete as a standard of reference, there is appended certain statistical information relating to each vessel, including tonnage, and exact position and height of standard compass: these details will be found necessary in a critical examination of the magnetic characteristics of ships in general.

In the analysis of the Deviation Tables, I have employed Mr. ARCHIBALD SMITH'S formula for computing the magnetic coefficients, as deduced from POISSON'S General Equations given in the Supplement to the "Practical Rules for ascertaining and applying the Deviations of the Compass caused by the Iron in a Ship," furnished to Her Majesty's Ships; and also in the Philosophical Transactions for 1846.

In this formula the deviation (δ) of the compass on board ship, reckoned positive when the north point of the needle deviates to the east, is given by the following expression:—

$$\delta = A + B \sin \zeta' + C \cos \zeta' + D \sin 2\zeta' + E \cos 2\zeta',$$

A, D, E being constants depending only on the amount, quality, and arrangement or position of the iron in the ship; B and C depending on these, and also on the magnetic dip and horizontal intensity; and ζ' the azimuth (by disturbed compass) of the ship's head, reckoned from the magnetic north to the east.

This formula is only approximate; but is sufficiently correct when the deviation does not exceed about 20°. The accurate formula involves calculations too laborious to be applied to ordinary cases.

Without entering on the nature and action of the magnetic forces which cause the deviation of the compass on board ship,—to be found in the works to which I have alluded, as also in the introduction to Dr. SCORESBY'S late Voyage round the World for magnetical research, edited by Mr. ARCHIBALD SMITH,—further than to attach a physical meaning to the coefficients for practical elucidation, it is necessary to premise that the investigations of the Astronomer Royal* are in accord with the general terms

* "Account of Experiments on Iron-built ships, instituted for the purpose of discovering a correction for the deviation of the Compass produced by the Iron of the ships," Philosophical Transactions, Part I. 1839. "Discussion of the observed Deviations of the Compass in several ships, Wood-built and Iron-built: with a General Table for facilitating the examination of Compass Deviations," by G. B. AIRY, Esq., Astronomer Royal, Philosophical Transactions for 1856.

of this formula; observing, that in those investigations the coefficients A and E are eliminated by the assumption that the soft iron is symmetrically distributed on each side of the fore-and-aft line of the ship.

The meaning of the several coefficients is as follows:—

A is a constant deviation, real or apparent; + if easterly deviation is in excess, − if westerly; when real, it arises from the induction of the horizontal force of the earth on masses of soft iron unsymmetrically distributed; when only apparent, as in nearly every case recorded, it is considered due to prism, or index error of the compass on board, or of the compass employed on shore in obtaining reciprocal bearings, as also local disturbance of the latter; and, when the deviation has been observed by the bearing of a distant object, that the latter has been imperfectly determined.

B and C are due to the combined effects of the permanent magnetism of the hard iron; the deviation produced by which varies inversely as the horizontal force at the place, and that induced by the vertical part of the earth's force on the soft iron in the ship, the deviation produced by which varies as the tangent of the dip. This deviation has been termed "polar-magnet" by the Astronomer Royal, and "semicircular" by Mr. A. SMITH, from the nature and appearance of the curve when graphically delineated.

B represents that part of the combined attraction acting in a fore-and-aft direction; + if before the compass, − if abaft it; that is, the north end of the needle is attracted to the bow in the former case, and to the stern in the latter.

C is that portion of the combined attraction acting in an athwart-ship direction; + if the north end of the needle is drawn to the starboard side, − if drawn to the port side of the ship.

D and E, known as the permanent coefficients, from their (theoretically considered) unchanging value in all magnetic latitudes, are due to the horizontal induction of the soft iron in the ship, and produce a "quadrantal" deviation; the term multiplied by D having its four maxima at the intercardinal points, and that by E at the cardinal points.

The values of D are considered by theory to arise from masses acting in a fore-and-aft, or transverse direction; + from those before or abaft, − from those on either side.

E is in general so small as to be practically unimportant.

Tables of Magnetic Elements of various Ships in Her Majesty's Navy, Iron and Wood-built.

The results of the analysis of the Tables of Compass Deviation are thus arranged:—

Table I. The iron-built vessels arranged according to tonnage: this analysis includes every Deviation Table of such vessels recorded in the Admiralty.

Table II. includes the floating batteries; one iron-built, and the others wood-built plated with iron.

Table III. A selection from the wood-built screw steam-vessels, embracing those of large, medium, and small dimensions.

Table IV. A selection from the wood-built paddle-wheel steam-vessels, embracing vessels of various dimensions.

The selected examples of Tables II. and III. must be understood as adopted to represent the general types of their classes: the examples in these Tables, of deviations observed on Foreign stations, are selected from the evident skill and care that has been bestowed on the observations, and from their perfect illustration of the general nature of the magnetic change in wood-built steam-ships.

Table V. The magnetic coefficients of the steam-ship Great Eastern, as observed in various parts of the vessel by myself, conjointly with Mr. RUNDELL, the Secretary to the Liverpool Compass Committee.

The general tabular arrangement it is considered requires little further explanation than the titles of the various columns convey. The column "Ship's force to head" is the natural sine of the corresponding value of the coefficient B, and is in fact the proportion of the ship's force to head, to the earth's horizontal force. The column "Ship's force to starboard" is the natural sine of the corresponding value of the coefficient C, and is the proportion of the ship's force to the starboard side, to the earth's horizontal force.

The resultant of B and C is the ship's force, and is in its direction $\left[\tan^{-1}\frac{C}{B}\right]$ and amount $[\sqrt{B^2+C^2}]$ the equivalent of the "true starboard angle" (measured from the bow round by the starboard side to the bow again), or "neutral position;" and of the "modulus" of polar-magnet deviation in Mr. AIRY's paper in the Philosophical Transactions for 1856.

It will be observed that in the results obtained from Deviations observed on Foreign stations (noted in *italics*), the total force of the ship is given in two lines, the upper line being the proportion of the ship's force to the horizontal force of the earth at the place, the lower line being the proportion of the ship's force to the horizontal force in England, so as to allow a comparison to be made of the absolute force of the ship at various stations.

For convenience, 1·000 has been adopted to represent the value of the earth's horizontal magnetic force at the several English ports where Her Majesty's ships are usually swung, viz. Greenhithe, Sheerness, Portsmouth, and Plymouth: for other stations I have adopted those given by Mr. AIRY in the paper of 1855 alluded to; and for several places not included in his discussion, reference has been made to the chart of Absolute Magnetic Intensity by General SABINE*, employing for the reduction to the horizontal component, the most recent determinations of the magnetic dip with which I am acquainted.

A comparative Table of the foregoing elements, with the horizontal force as given by GAUSS in his 'Atlas des Erdmagnetismus,' reduced to the same unit of measure, is appended, as being probably of use in any future inquiry or discussion.

I now proceed to direct attention to various features exhibited in the several Tables,

* KEITH JOHNSON'S 'Physical Atlas,' 2nd edition.

and shall venture to suggest what would appear from fair inferences to be the leading principles of the magnetism of the ships included therein, and their practical application.

It has been deemed unnecessary to introduce an analysis of the compass deviations of wood-built *sailing* vessels; as, whether as ships of war with batteries of guns, or merchant vessels carrying cargo,—always excepting iron,—their deviations are small in amount, and arising in the aggregate from induced magnetism.

An intercomparison of the magnetic coefficients of iron and wood-built steam-ships is of greater importance in the investigations of the laws affecting the former, than would at first appear: the special points elicited are—

That D, which in the iron vessel ranges in value from $+1\frac{1}{2}°$ to $+6°$ and $7°$ (the Liverpool Compass Committee recording even a point or $11°$), seldom exceeds $+1°$ in wood screw-ships, with not unfrequently a small *minus* sign in these vessels, and $+1\frac{1}{2}°$ in the wood paddle-wheel steam-ships.

A and E appear common in character and value in all the classes of vessels enumerated.

B and C thus differ:—In the wood-built vessel (in Great Britain) B is $+$ whenever the engines are before the compass, and C is always small in value. In the iron-built vessel, B, irrespective of the machinery, is either $+$ or $-$ as the ship's head while building was south or north; and C may be large in value, either $+$ or $-$; B nearly vanishing as the ship's head while building deviated from the magnetic meridian and approached the east or west points of the compass*.

Taking therefore the relative tonnage, horse-power, and position of the standard compass in each class of vessel, wood and iron, a judgment can be formed of the comparative magnetic effects of the engines and boilers, apart from the hull or hammered fabric of the iron ship.

Several examples occur in the Tables; from which we may infer, (1) that in an iron vessel built in England, head *south*, the north end of the needle is drawn to the bow, or B is positive. The steam machinery has the same effect; B therefore as due to the hull, is increased in amount. (2) In an iron vessel built head to the *north*, the north end of the needle is drawn to the stern, or B is negative; the steam machinery will in this case tend to diminish the value of this coefficient; and on reference to Table I. it will be observed that, as a rule, those vessels with B positive have, taking size and other conditions of compass position into consideration, large compass deviations.

But what are the combined effects of steam machinery and hull on a great change of geographic position, or in high south magnetic latitudes? An examination of the several Tables elicits some valuable information on this important point.

* The connexion between the direction of the ship's keel and head while building as referred to the magnetic meridian, and the direction and strength of her magnetic polarity, so fully experimented on by the late Dr. Scoresby and the Liverpool Compass Committee, is, I consider, fully confirmed; and there will be added to this Report the magnetic lines of the 'Great Eastern,' as another example of this remarkable feature of an iron ship's magnetism.

Referring to the magnetic changes of the *wood-built* vessels (screw or paddle) in the progress of their respective voyages to, and in the southern hemisphere, of which there are several good continuous examples, it is evident that the coefficients B and C are dependent in their change chiefly on the alteration of the magnetic dip, and that the horizontal intensity is a minor element of disturbance; it may therefore be inferred as a general rule, that in steam machinery, permanent magnetism bears but a small proportion to inductive.

This appears sufficiently from examples in Tables III. and IV.; as also that, as in the case of wood-built sailing vessels (discussed by General SABINE in the Philosophical Transactions for 1849 *), the wood steam-ship's magnetism, on rapid changes of geographic position, falls short of, or "lags behind," the amount theoretically due to changes of magnetic latitude.

The wood screw-ships Plumper and Highflyer † are instructive examples of the "lagging behind" of their magnetism; in the former case, on the ship's arrival at Vancouver Island, the semicircular deviation was much in arrear of the value due to the magnetic dip, as compared with that originally obtained in England. After an interval of sixteen months, on the ship being reswung in the same locality, which she had not quitted, the deviations exceeded the original amount observed in England, approximating to the value due to the increased magnetic dip at Vancouver Island. Similar features are exhibited in the Highflyer employed in the China seas.

We have now to consider the magnetic nature of the hull of the iron vessel combined with the steam machinery; and in stating here the fact, of the former being, in the majority of the vessels investigated, highly permanent and but slightly inductive, in contradistinction to the steam machinery, I am only anticipating what will be hereafter given in proof from examples in Table I.

The position of the standard compass with reference to the steam machinery in an iron vessel, has therefore an important bearing practically and theoretically; for if it is placed in proximity to the funnel, which may be considered as the zero or measuring point for the machinery in general, the inductive magnetism of the machinery is superadded on the subpermanent magnetism of the hull, and complicates the question apparently beyond research.

An instructive practical example of this condition is afforded in the case of the 'Vulcan' iron ship: in this vessel the steam machinery is further aft than is usual in ships either of the Navy or of the mercantile marine; and it will be observed that the standard compass is only 27 feet distant from the funnel, and is elevated on the poop-deck nearly to the level of the top of the latter. Viewing the nature of the Vulcan's hull under the conditions of permanent magnetism, the maximum deviation, or ship's force,

* Contributions to Terrestrial Magnetism, Part IX.

† Commanded respectively by Captains GEORGE H. RICHARDS and CHARLES F. SHADWELL, C.B. The labour and attention bestowed by these officers in the determination of the compass deviations of their ships, and the consequent value of the results to the practice of navigation, and the theory of a ship's magnetism, are worthy of especial record.

when at the Cape of Good Hope, should have been reduced in the inverse proportion of 1·000 to 1·174, or about one-sixth, whereas by observation it had more than doubled: the polarity of the funnel and machinery, following the changes of magnetic dip (the vessel was some months employed in high south magnetic latitudes), was reversed, and thus their force of magnetism (−B) was added to that of the hull of the ship (−B also), instead of being subtracted from it, as had been the case in England.

The Simoom, a nearly sister vessel to the Vulcan, but with +B, and also observed at the Cape of Good Hope, has the conditions reversed, the semicircular deviation being smaller than its theoretical value, for the opposite reason; viz. that the force of the machinery which had been added to that of the hull in England, changing its sign, was subtracted from it at the Cape of Good Hope.

On the Nature of the Magnetism in Iron-built Ships.

The magnetic influence of steam machinery having been reviewed, the nature of the magnetism of iron-built ships can be entered on free, to a certain extent, of conditions arising from this extraneous source of compass error, and those examples fairly eliminated where it tends to embarrass the discussion.

The investigation of the coefficient D, or the disturbance arising from the horizontal induction of the soft iron in the ship, when extended over the numerous examples recorded in Table I., offers several novel and suggestive points of inquiry: the chief characteristics are,—

1. That it has invariably a *positive* sign, causing an easterly deviation in the N.E. and S.W. quadrants, and a westerly deviation in the S.E. and N.W. quadrants.

2. That its amount does not appear to depend on the size or mass of the vessel, or direction when building, or on the iron beams.

3. That a gradual decrease in amount has occurred, when examined over a number of years, in nearly every vessel that has been reviewed.

4. That the value remains unchanged in sign and amount, on changes of geographic position, confirming theoretical deductions.

5. That a value for this coefficient, not exceeding 4°, and ranging between that amount and 2°, may be assumed to represent the average or normal amount in vessels of all sizes.

The following examples support these propositions:—

1. The value not depending on the size of the vessel.

		°	′		°	′
Great Eastern, of 22,000 tons	.	+4	8	Trident, of 850 tons	+3	26
Himalaya . „ 3,453 „	.	+3	18	Oberon, „ 649 „	+3	23
Assistance . „ 1,820 „	.	+3	36	Onyx, „ 292 „	+3	42

As also, that the effect of iron beams, which has been assumed as a large element of disturbance, cannot be traced.

{ Assistance	1820 tons,	iron beams	+3° 36
{ Trident	850 tons,	wood beams	+3 26
{ Industry	638 tons,	iron beams	+2 40
{ Oberon	649 tons,	wood beams	+3 27
{ Bloodhound	378 tons,	iron beams	+3 40
{ Sharpshooter	503 tons,	wood beams	+4 32

To establish the effect of iron beams more fully, I carried out a series of experiments on board H.M.S. Supply; and from the results it is to be inferred that their magnetic character is identical with that of the hull of the ship; being dependent, as regards polarity and permanency of magnetism, on the direction of the ship when building, and the nature of the iron.

The uniformity of the quadrantal deviation of the compass, when placed in various positions and at different heights from the deck, is thus shown:—

		ft. in.		° ′
In middle line of the 'Supply,'	28 feet from stern,	5 0	high from deck	+2 38
”	19 ”	5 2	”	{ +2 15 +2 37
”	12 ”	3 10	”	+2 55

Placed 22 feet from stern, 3 feet from middle line of deck, and 3 ft. 9 in. high . . . +2 56

Placed 13 feet from stern, 8 feet from middle line of deck, 2 feet from the iron top side, and 1 foot 8 inches high . . . . } +2 13

The polar-magnet or semicircular deviation varied under these conditions from 15° to 45°.

Elevation of the compass above an ordinary height from the deck necessarily diminishes the amount of quadrantal deviation, as in mast-compasses *; but within the ordinary limits, or from 2 to 6 feet from the deck, the foregoing examples show that the value is not affected. Another example was also afforded in H.M.S. Assistance, where the raising the standard compass from 4 feet 5 inches to 6 feet 4 inches above the iron beams, which diminished the "semicircular" deviation from 17° 40′ to 15°, had no perceptible effect on the "quadrantal," the values of D being respectively +3° 35′ and +3° 36′.

		Mast-compass, 45 feet from deck.	Standard compass, 5 feet from deck.	
* Great Eastern	River Thames	+1° 32′	+4° 21′	Coefficient D.
	Portland	+1 30	+4 44	
	Holyhead	+1 0	+4 8	

H.M.S. Trident, mast-compass elevated 48 feet from the deck, D−1° 8′: this is the only example that has come under my investigation of a *minus* sign. It is the effect which would be produced if the soft iron can be considered as collected in two masses,—one near the bow, the other near the stern.

2. The gradual decrease in the value of D is well marked in those ships in which the position of the compass has remained unchanged, and direct comparison has been thus afforded.

Himalaya	in	4½	years, decrease from	3° 51′	to	3° 18′ =	0° 33′
Urgent	,,	4	,, ,,	2 58	,,	2 12 ,,	0 46
Simoom	,,	7¾	,, ,,	3 57	,,	3 25 ,,	0 32
Vulcan	,,	8½	,, ,,	3 20	,,	2 48 ,,	0 32
Birkenhead	,,	4	,, ,,	2 53	,,	2 12 ,,	0 41
Trident	,,	13	,, ,,	4 03	,,	3 26 ,,	0 37
Triton	,,	9½	,, ,,	4 02	,,	2 37 ,,	1 25
Supply	,,	5¼	,, ,,	3 40	,,	2 15 ,,	1 25
Bloodhound	,,	10	,, ,,	3 40	,,	2 31 ,,	1 9
Jackal	,,	14	,, ,,	4 57	,,	3 01 ,,	1 56
Myrmidon	,,	9¼	,, ,,	3 23	,,	2 45 ,,	0 38
Harpy	,,	14	,, ,,	2 54	,,	2 32 ,,	0 22
Lizard	,,	13	,, ,,	3 49	,,	3 4 ,,	0 45
Onyx	,,	4	,, ,,	3 42	,,	3 26 ,,	0 16
Dover	,,	5½	,, ,,	2 38	,,	2 23 ,,	0 15

3. In assuming the normal amount of quadrantal deviation in iron steam-ships as from 2° to 4°, it will be seen, from the accompanying analysis, that thirty-four of the forty-two ships in Her Majesty's Navy, or 75 per cent., are included in this condition, thus:

Quadrantal deviation, between	1°	and 2°,	2	vessels,	of 1391 and 462* tons.
,, ,, ,,	2	,, 2½,	1	,,	164 tons.
,, ,, ,,	2	,, 3,	11	,,	1981 to 180 tons.
,, ,, ,,	2½	,, 3½,	10	,,	1764 ,, 270 tons.
,, ,, ,,	3	,, 4,	10	,,	3453 ,, 292 tons.
,, ,, ,,	3½	,, 4½,	3	,,	1980 ,, 503 tons.
,, ,, ,,	3	,, 5,	2	,,	440 ,, 340 tons.
,, ,, ,,	4	,, 5,	1	,,	267 tons, as also Gt. Eastern.
,, ,, ,,	6	,, 7,	2	,,	1954† to 267 tons.

Two questions of import here arise:—Are the results of this analysis to be deemed conclusive? and, if so, under what conditions do large quadrantal deviations occur?

It will be remembered that the two earliest iron vessels experimented on by Mr. Airy,—the 'Rainbow' in 1838, and the 'Ironsides' in 1839,—vessels probably in those

* A sailing vessel.

† A floating battery.

early days considered experimental, and built of the best material, had very small quadrantal deviations, viz. 1° and 1° 6′ respectively; indeed the Astronomer Royal experienced difficulty in tracing the effects of terrestrial induction. Bearing these facts in view, and taking further into consideration that in building Government vessels stringent conditions of contract as to soundness of material are enforced, and strict supervision exercised, it may be fairly assumed that the amount given of 2° to 4° represents the average condition of a well-built ship of the best or superior iron.

On the other hand, can the inference be drawn that an iron ship with large quadrantal deviation implies inferior material being used in her construction?

Two of the most disastrous and fatal shipwrecks on record have occurred to iron-built vessels, whose magnetic characters are perfectly known. H.M.S. Birkenhead, whose permanency of magnetism (Table I.) was especially constant, and quadrantal deviation small,—$2\frac{1}{4}°+$ a short time prior to her loss,—may be considered as the type, magnetically, of a "hard" iron-built ship: the Royal Charter, with a quadrantal deviation of 6°, and whose sub-permanent magnetism fluctuated more than any vessel with whose records I am acquainted, may be considered as the type, magnetically, of a "soft" iron-built ship. It will be recollected that in the wreck of these vessels under their varied circumstances, both parted amidships; the Royal Charter so suddenly and rapidly, as to invite serious attention to various points of her construction.

It is difficult to draw any comparative conclusions from these two cases, but they are placed in juxtaposition as grounds for further inquiry as to the connexion between the amount of quadrantal deviation and the nature of the iron of the ship; and it will be remarkable and not less useful, if, in the prosecution of such inquiry, it can be established that the relative qualities of the material used in iron ship-building can be discriminated by the subtle agency of the ship's compass-needle.

On the Coefficients B *and* C *in Iron-built Ships, or that part of the Compass-disturbance arising from the permanent magnetism of "hard" iron, and that induced by the vertical part of the earth's force on the "soft" iron in the ship.*

On examination of Table I., it is at once observed that in the majority of examples therein given, a permanency of magnetism exists so little affected by changes of geographic position, as materially to confirm the views entertained by the Astronomer Royal in his earliest discussion (1838), that the effect of transient induced magnetism in iron-built ships is very small comparatively.

The absence of irregular fluctuations, and the gradual diminution of the ship's force, analogous to the gradual decrease of the quadrantal deviation, are notable features; and apparently the general permanency is but little influenced by concussions from the sea, or from the repairs in dock, which necessarily must have occurred during the several years over which the observations extend.

The gradual diminution of the ship's magnetic force is shown in the following

examples, all determined in English ports, and where it has been ascertained that, from the compass remaining in the same position, the results are comparative.

The column "semicircular" deviation has been added to show the practical disturbance on the compass at its maximum.

Year.	Ship's force. Direction.	Ship's force. Amount.	Semicircular deviation.
Himalaya.			
1855.	182°	0·275	16° 0′
1856.	182	0·243	14 5
1859.	169	0·248	14 25
Urgent.			
1855.	175	0·215	12 25
1856.	170	0·183	10 35
1857.	158	0·163	9 25
1859.	170	0·151	8 45
Simoom.			
1852.	340	0·367	21 35
1852.	340	0·367	21 35
1857.	355	0·326	19 0
1859.	4	0·316	18 30
Megæra.			
1851.	190	0·232	13 25
1852.	150	0·238	13 45
1857.	162	0·219	12 40
Birkenhead.			
1847.	205	0·264	15 15
1847.	206	0·265	15 20
1848.	206	0·260	15 5
1850.	207	0·264	15 15
1851.	206	0·267	15 30
Trident.			
1846.	3	0·345	20 10
1848.	359	0·359	21 0
1849.	360	0·316	18 36
1852.	352	0·342	20 0
1856.	351	0·376	22 5
1859.	2	0·320	18 40
Caradoc.			
1848.	199	0·230	13 20
1855.	191	0·193	11 10
Triton.			
1848.	178	0·207	11 55
1852.	198	0·142	8 10
Oberon.			
1847.	294	0·266	15 25
1851.	295	0·230	13 20

Year.	Ship's force. Direction.	Ship's force. Amount.	Semicircular deviation.
Industry.			
1854.	13°	0·247	14° 20′
1856.	13	0·256	14 50
1858.	358	0·230	13 20
1858.	354	0·182	10 30
1859.	360	0·185	10 40
Sharpshooter.			
1848.	177	0·126	7 15
1850.	180	0·105	6 5
1852.	180	0·280	16 15 *
1857.	189	0·235	13 35 *
Bloodhound.			
1845.	351	0·256	14 50
1847.	351	0·209	12 5
1851.	347	0·219	12 40
1855.	350	0·207	12 0
Jackal.			
1845.	353	0·288	16 45
1849.	344	0·266	15 25
1854.	329	0·316	18 25 *
1859.	339	0·262	15 10 *
Lizard.			
1845.	351	0·236	13 40
1853.	3	0·188	10 50
1858.	5	0·172	9 55
Firequeen.			
1847.	320	0·210	12 10
1852.	329	0·197	11 20
Fairy.			
1850.	355	0·233	13 30
1852.	357	0·202	11 40
1858.	10	0·201	11 35
Princess Alice.			
1844.	2	0·257	14 55
1850.	358	0·225	13 0
1855.	348	0·213	12 20
Torch.			
1846.	340	0·206	11 50
1852.	356	0·186	10 45

* Position of the compass changed since the earlier determinations.

Examples of permanency of ship's force on changes of geographic position are exhibited in the following vessels; in which, for the sake of comparison, the modulus has been multiplied by the horizontal intensity at the place.

Urgent.

	Ship's force.	
Year.	Direction.	Amount.
1855. England	176°	0·215
1855. Malta	184	0·189
1856. England	170	0·183

Megæra.

1852. England	150	0·238
1853. Antigua	145	0·213
1857. England	162	0·219

Triton.

1852. England	198	0·142
1852. Corfu	200	0·142
* 1857. England	213	0·178
* 1858. Fernando Po	181	0·188

Oberon.

1851. England	295	0·230
1856. Malta	297	0·201
* 1858. England	323	0·180
* 1858. Monte Video	303	0·179

Bloodhound.

1845. England	351	0·256
1846. Constantinople......	347	0·281
1846. Athens	344	0·249

Assistance.

1857. England	129	0·259
1858. Canton	119	0·274

Adventure.

1857. England	124	0·305
1858. Whampoa, China...	118	0·307

Caradoc.

1848. England	199	0·230
1852. Malta	189	0·258
1855. England	191	0·193
1857. Malta	191	0·229
1858. Malta	200	0·242

Industry.

	Ship's force.	
Year.	Direction.	Amount.
1856. Malta	359°	0·240
1856. England	13	0·256

Sharpshooter.

1852. England	180	0·280
1853. Rio de Janeiro ...	189	0·253
1857. England	160	0·235
1857. Isles de Los, Africa	172	0·222

Jackal.

1845. England	353	0·288
1846. Athens...............	355	0·274
1847. Lisbon	352	0·260

Trident.

1846. England	363	0·345
1847. Malta	357	0·359
1848. England	360	0·359
1852. England	353	0·342
1852. Rio de Janeiro......	351	0·368
1856. England	351	0·376
1857. Ascension Island...	342	0·373
1857. Cape of Good Hope	354	0·333
1859. England	363	0·320

Harpy.

1854. England	5	0·152
1857. Malta	352	0·166

Wilberforce.

1843. England	223	0·185
1843. River Gambia......	222	0·193

Torch.

1852. England	356	0·186
1852. Madeira	348	0·153
	352	0·161
1852 St. Vincent Island	350	0·198
1852. Rio de Janeiro......	351	0·219
1852. Tristan d'Acunha	337	0·189
1852. Cape of Good Hope	3	0·190
1853. St. Paul's Island ...	357	0·198
1853. Swan River.........	358	0·182
1853. K. George's Sound	352	0·214
1856. Australia	3	0·246 approx.

* Position of compass changed since the earlier determinations.

The Torch is a special example. This vessel was sold out of Her Majesty's service at Sydney, after a continuous service of three years in Australia (1853 to 1856) in high south magnetic latitudes; in July 1856 she was chartered by the Colonial government of New South Wales to proceed to the northern coast of Australia to render assistance to an exploring expedition. The officer who had previously been in command, Lieut. Wm. Chimmo, R.N., was the Government agent on this occasion, and on the passage, especially along the eastern shores of Australia, that officer made numerous observations for the Variation of the Compass (the direction of the ship's head being noted to each), which were transmitted to the Admiralty. From these observations, compared with the well-known variation in these seas, I was enabled graphically to construct a curve of deviation: the results are given, and are confirmatory of the general permanent nature of the ship's magnetism under circumstances which I apprehend are novel, and not without value in a theoretical discussion.

The conclusions derived from a review of the foregoing results are not unimportant; and not the least of these in practical value, is that in an iron ship of ordinary dimensions, and of conditions similar to the examples quoted, a standard compass can be placed, the deviations of which will but little exceed those obtaining in wood-built steam-ships; and further, that on a change of geographic position, however great, these compass deviations will be within smaller limits, and can be approximately predicted.

A divergence from these conditions will arise when the inductive magnetism of the hull or machinery predominates. If we may judge from the case of the Royal Charter, whose magnetic elements have been so ably discussed by various authorities, large quadrantal deviation and fluctuating sub-permanent magnetism (due to hull alone) are coexistent, and give rise to conditions of compass-disturbance which are beyond prediction, have hitherto baffled inquiry, and given a complexion to theoretical deductions varying as regarded from different points of view.

Obser tions on the early changes of an Iron-built ship's Magnetism, illustrated by experiments in the Steam-Ship Great Eastern.

The opinion has been long entertained, that the original magnetism of an iron-built ship, or that acquired in the process of building, undergoes a rapid change after launching, and that from this cause accidents have occurred to recently launched and hastily equipped vessels. The records of ships of the Royal Navy do not illustrate this subject.

The unusual dimensions of the Great Eastern, and the interest attaching to the progress and success of so great an undertaking, pointed her out as a desirable ship to test in elucidation of various problems connected with the mariner's compass, and especially of the supposed early changes in the ship's magnetic force.

Through the kindness of the Directors, and partly in the nature of assistance sought for by that body from the Lords of the Admiralty, I was enabled to make many

observations, the results of which, so far as they relate to the early changes in the deviations of the compass, and the external magnetic lines of the ship, will be found in Table V., and an accompanying diagram in Plate XV.

In the progress of building (18th August, 1857), I ascertained by astronomical bearings, with the known variation of the compass at the time, that the magnetic direction of her keel and head was S. 29° 50′ E. A short time previous to the launching (November 1857), I also obtained the few results for the external magnetic lines, which will be found in the diagram.

After launching, the Great Eastern was secured near Deptford dockyard, with her head S. 46° E. magnetic; differing only 16° from the original direction while building; considerable works, chiefly internally, were in progress till the time of quitting this anchorage. In August 1859, a few days prior to leaving the river, an extended series of observations for the development of the external magnetic lines (see diagram, Plate XV.) was obtained; which show that some alteration had taken place since the first approximate determination.

On September 7th, 1859, the Great Eastern quitted Deptford on her preliminary trip to Portland, arriving at the latter port on the 10th. On the passage between these places, which included temporary anchorages at Purfleet and the Nore, every opportunity was embraced of determining the deviations of the compass at various selected stations in the ship which are marked in the diagram. The deviations whilst in the River Thames were determined by noting the difference between the bearing of the ship's head, as astronomically determined (by the use of a repeating card, and prepared table of the sun's bearings), and as denoted by the compass: a curve of deviations embracing each point of the compass was then graphically drawn through the general results.

At Portland, lying within the breakwater, the correct magnetic bearing of St. Alban's Head, a distant point of land, afforded ready means of determining the deviations as the vessel swung round at her anchor; and subsequently at Holyhead, where I proceeded again in conjuction with Mr. RUNDELL, similar means were adopted as at Portland by the bearing of a distant Welch mountain. As it was not possible to "swing" the Great Eastern, from her ponderous bulk, in the mode usually adopted under these circumstances with ordinary sized vessels, we were dependent on the changes of ship's head arising from winds and tides: this necessarily occupied much time, and was the occasion of gaps being left in the curves of deviations obtained both at Portland and Holyhead, which required to be arbitrarily filled up. As these curves presented no anomalous differences from those of ordinary sized ships, but were marked by perfect regularity and consistency among the observations, these gaps were confidently completed.

From a consideration of the magnetic character of the Great Eastern, it is apparent that the Admiralty Standard compass, as also the ship's Standard compass, were placed in the best position with respect to the hull and machinery, both for experimental research and the navigation of the ship; indeed, from the vast amount of machinery and neces-

sarily inductive material running nearly fore and aft the vessel, I am disposed to attach but little comparative value to any of the results except those of the Admiralty Standard compass, as it will be seen that the other compasses are influenced by the near proximity of steam funnels or iron masts.

Directing attention to the changes in the magnetism of the ship as indicated by this compass, the gradual diminution of the ship's force is marked at each successive period of observation, and also the constant tendency to attain a fore-and-aft direction. In the first five days, from Deptford to Portland, the force had diminished from 0·585 to 0·480, nearly one-fifth, or the semicircular deviation decreased from 35° 50′ to 28° 45′; the direction of force, or neutral points, approaching a fore-and-aft line 10°, or from 47° on the starboard bow to 37°: it is here worthy of remark, that the general direction of the ship's head for three days at Portland out of the five named, was N.W., or exactly opposite to her direction whilst lying at Deptford.

The change at the expiration of the next six weeks, the ship in the interim having made the passage to Holyhead, with some trifling rough weather, still shows a diminution of force, and tendency to the fore-and-aft direction of the neutral points of disturbance: the former is reduced from 0·480 to 0·390, or about one-sixth (the corresponding semicircular deviation being 28° 45′ and 23° 0′); and the latter changed 5°, or from 37° to 32°.

The changes denoted by the mast and platform compasses do not follow the same progressive decrease and change of direction of ship's force. To the less perfect observations of the mast-compass, arising from the difficulty of obtaining readings aloft, and from the friction of blunted pivots after a few weeks' wear and tear, can be traced the probable causes for this instrument; the unfavourable but unavoidable position for the platform compass has been adverted to.

The quadrantal deviations of all the compasses show a decrease, so far confirmatory of the law that exists in the numerous vessels reviewed; but there is an anomaly detected by Mr. AIRY* in the quadrantal disturbance of the Admiralty Standard compass worthy of record, viz. that it is larger in the quadrant from west to north; the position opposite to that in which the ship was built.

	1st, or N.E. quadrant.	2nd, S.E.	3rd, S.W.	4th, N.W.
River Thames . .	+4° 33′	−2° 40′	+4° 8′	−6° 6′
Portland	+4 38	−3 8	+4 53	−6 37

Indication of rapid changes in the ship's magnetism was also given by the ship's established standard compass, which had been compensated on the passage down the river Thames (from the known direction of the ship's head by astronomical bearings), and deemed by the gentlemen engaged for the purpose as correct. At Portland, with head in the N.W. direction, it had 7° error on the second day at that anchorage.

* Communicated in a letter to Mr. RUNDELL, Secretary of the Liverpool Compass Committee.

This error, as also a smaller one considered to exist after the ship's arrival at Holyhead, was, as I understood, eliminated prior to my visit at that port in the latter part of October; but on then determining the deviations of the Admiralty Standard compass, and referring the results to the ship's compensated standard, a residual error in the latter of nearly 5° still existed on some of its points.

[Although the question of compensation is extraneous to the general tenor of this Report, I deem it of interest to record the above circumstances, to correct a misapprehension as to the employment of long needles, carried, in the compasses of the Great Eastern, to the extent of 11 inches for standard and steering, and 16 inches for the mast-compass. A series of experiments, still in progress, which I have instituted in elucidation of the comparative errors due to the use of long and short needles, both where the disturbing cause is comparatively close to the compass, as in the case of the rudder-head near the steering compass, or the top sides and iron beams when heeling, and in compensated compasses from the necessary proximity of bar magnets, lead to the conclusion that no compass-needle should exceed in length, for service in an iron ship, 6 or 7 inches; the card of course may be enlarged as practically convenient.

The errors of long needles, under the conditions just named, of proximity to permanent magnetic bodies, arise from this notable fact, that their deviations assume the form, not of a curve which is simply "semicircular," as the curve is found to be which results from the ship's general magnetic force when the length of the needle may be relatively considered as infinitesimally small, but of a "sextantal" superposed on a "semicircular" curve, the various maxima of the "sextantal" curve increasing with the square of the length of the needle. Assuming the zero of both curves (the semicircular and sextantal) to be at the magnetic North and South, the maxima of the sextantal deviations (by ship's compass) are respectively at about N. 30° E., East, S. 30° E., S. 30° W., West, N 30° W., the points of coincidence with the semicircular curve being at North, N. 60° E., S. 60° E., South, S. 60° W., and N. 60° W.]

The tendency of the direction of the ship's force in the Great Eastern is to assume a fore-and-aft line, supporting the view, that time, with the vibrations and concussions due to sea-service, leads to a settled distribution of the magnetic lines; the respective sections of the hull which have north and south polarity being separated by lines approximating more nearly to a horizontal equatorial plane through the body of the ship, instead of the inclined equatorial plane of separation due to the magnetic dip of the locality, and divergence from the magnetic meridian of the hull while building.

A similar tendency of the direction of the ship's force to approach a fore-and-aft line will be observed in several examples of Table I.

The example of the Great Eastern offers this practical information; that prior to a newly built iron ship being sent to sea, her head (while being equipped) should be secured in an opposite direction to that in which she was built; and that the magnetic lines should be assisted to be "shaken down" by the vibrations of the machinery in a short preparatory trip prior to the determination of her compass errors, or their com-

pensation; but especially that on the early voyages vigilant supervision should be exercised in the determination of the compass disturbances.

Another important point, which is generally neglected when compasses are adjusted by the aid of magnets in a newly built iron ship, is rendered manifest from the circumstances just detailed, namely, the necessity of the errors of the compass arising from the iron in a ship being determined and placed on record prior to its adjustment. Without the knowledge, to be derived from these observations, of the magnetic force of the ship, or the local disturbing cause (if such exists), all future changes of magnetism, and consequent errors of the compass, are the merest guesswork, both to those who adjust and the authorities in charge of the navigation of the ship.

Any future legislation for the security of the navigation of our mercantile marine with reference to iron-built ships, should secure the determination and record of these preliminary observations.

I have alluded to the importance of the conclusions to be derived from a review of the examples and cases given in this Report; for although varying conditions of compass disturbance exist, and the inference is irresistible that they arise from the nature of the iron employed in the construction of the hull of the ship, there is no doubt that, by attention to a few leading principles in the building and equipment of iron ships, the larger and uncertain sources of error may be modified and reduced within limits both of fluctuation and amount, that will not seriously compromise the safety of the ship in the hands of an ordinarily prudent seaman.

The points of practical import to which I would invite attention are,—

1st. The best direction, with reference to the magnetic meridian, for the keel and head of an iron ship to be placed for building, to ensure the least compass disturbance.

2nd. The best position and arrangement for a compass, to ensure small deviations, and permanency on changes of geographic position.

3rd. The changes to which the compass is liable from various causes when the foregoing conditions are fulfilled.

Before entering on these points, I would refer to an appended series of diagrams (Plate XVI.) illustrative of the polarity of the topsides (and the coefficients B and C), according to the direction of the build; these diagrams forming the key to much that comes under review.

1. *On the best Direction for Building an Iron Ship.*

In those built head N.E., East, West, and N.W., strong *south* polarity (or an *attractive* force on the north end of the compass needle) obtains on one side of the ship adjoining the compass as usually placed between the middle section and the stern; the resulting disturbance is not lessened as the compass is moved in a fore-and-aft line within these limits.

In vessels built head S.E. and S.W., *north* polarity obtains under the same conditions.

In vessels built head North or South, the conditions arise, that in the former the attraction is toward the stern (the topsides in their action being neutral to a compass in the middle line of the deck), and diminishes in force as the compass is moved towards the bow. In the latter the law is reversed, and small compass deviations are obtained as the stern is approached.

In an iron *sailing* ship, built head to South, there will be an attraction of the north point of the compass to the head, and if built head to North, a like attraction to the ship's stern; and so far there would seem to be no advantage in one direction over the other. But in the first case the topsides near the compass have weak magnetism; in the second case they are strongly magnetic: the first position seems therefore preferable.

In an iron steam-ship, built head to the South, the attraction due to machinery is added to that of the hull, whereas in one built head to the North, the attractive forces of hull and machinery are, in the northern hemisphere, antagonistic, and a position of small, or no "semicircular" deviation for the compass may generally be obtained. To iron steam-vessels engaged on the home or foreign trades in the northern hemisphere, this direction of build is therefore to be preferred.

2. *On the Position and Arrangements for the Compass.*

The position of compasses, whether standard or steering, must depend, as will have been observed from the foregoing conclusions, on the direction of the ship's build; that is, in those built head North the compass must be as far removed from the stern as circumstances will permit; in those built South, placed as near to the stern as convenient, without approaching so close to the rudder-head or iron taffrail as to cause the ship's general magnetism to be overpowered by the magnetic influence of those masses.

In ships built East or West there is little choice of position, except to avoid, as a general rule, proximity to vertical masses of iron; in vessels built with their heads on the intercardinal points, a position approximating to the bow or stern respectively, where the action from the topsides (to be determined experimentally) is at a minimum, is to be preferred.

Ample elevation above the deck, and to be strictly confined to the middle line of the ship, are the primary conditions of position for every compass in an iron ship, and no compass, whether steering or standard, should be nearer the iron deck beams than 4 feet*: for the steering compass this arrangement could be met by the use of a vertical card for the helmsman.

The standard compass, which as a rule I should recommend to be invariably uncompensated, requires an elevation of at least 5 or 6 feet from the deck, and to be fitted on

* A curious illustration of the effect of iron deck beams on long and short compass-needles resulted from some experiments made on board H.M.S. Bloodhound: on the deck, or within a few inches of the position where, not unfrequently, hanging or tell-tale compasses are placed, a 10-inch needle had 43°, a 6-inch needle 38°, and a $1\frac{1}{2}$-inch needle 33° difference from their uniform deviation at 1 foot 9 inches from the deck.

a separate and permanent pillar or stand: it is by this superior elevation that the strong magnetic power of the iron beams and adjoining topsides are correspondingly lessened.

As every piece of iron not composing a part of, and hammered in the fabrication of the hull,—such as the rudder, funnel, boilers and machinery, tanks, cooking galleys, fastenings of deck houses, &c.,—are all of a magnetic character differing from the hull of a ship, their proximity should be avoided, and, so far as possible, the compass should be placed so that they may act as correctors of the general magnetism of the hull.

A compass placed out of the middle line of the deck is affected by the nearest topside, and its deviations must necessarily be much increased if that topside has the dominant polarity, as in ships built East or West.

Experience has proved that the practical value of mast or elevated compasses has in some cases been overrated; they are, in fact, affected by the ship's magnetism to an amount depending on their elevation and the direction of the ship's build: thus in ships built North or South, but especially the latter—the compass being on the mizen mast—the deviations will be large comparatively. In ships built East or West the deviations will be comparatively small, from the topside, which would affect a deck compass, being more directly under the mast-compass; they may therefore be useful in the latter cases, and valueless in a ship built head to the South. The wear and tear on the pivots and agate caps of mast-compasses, from the increased motion due to their elevation, require constant attention when they are employed.

3. *On various Sources of Error affecting a Compass placed under favourable conditions.*

Errors arising from changes of geographic position, as also incidental causes of error due to anomalous rather than general conditions, have been brought under review in the general progress of this Report. There is, however, one source of compass-error—that arising from the heeling of the ship—which has not been alluded to, as the ship in all the points hitherto reviewed is assumed to be on an even keel.

The few experiments made in ships of the Royal Navy will be found in Table I., and they tend to prove, as also does the test of experience, that when the original compass deviations are small, the errors from heeling are generally small in proportion; and conversely, that exaggerated errors from heeling are the consequence of exaggerated errors while on an even keel. Ample elevation from the deck, in order to raise the compass above the level of the topsides and adjacent deck beams, is one of the chief conditions for reducing this source of error.

The action of the topside nearest to the compass when the ship is heeled is well marked in the examples of the ships Bloodhound and Sharpshooter, the former with $+$B, or head built to South, and the latter with $-$B, or head built to North; in the Bloodhound the north end of the needle is drawn to *leeward*, in the Sharpshooter to *windward*. In the iron sailing-brig Recruit, with $+$B, the effect is the same as in the Bloodhound.

From the diagrams illustrative of the polarity of an iron ship's topsides, the action of

the latter on the compass in heeling may be gathered, and the corresponding effect shown, under the various directions of the ship's head in building: thus—

With head built	North,	on heeling,	the north end of compass needle will be *attracted* to the weather or nearest side from its *south* polarity.
,,	N.E.,	,,	,, the same.
,,	East,	,,	,, the same.
,,	S.E.,	,,	the north end of needle will have but little error from the balanced conditions of north and south polarity of topsides.
,,	South,	,,	the north end of needle will be *repelled* to the lee side by the *north* polarity of nearest or weather topside.
,,	S.W.,	,,	the north end of needle will have but little error, as at S.E.
,,	West,	,,	the north end of needle will be *attracted* to the weather or nearest side.
,,	N.W.,	,,	,, the same*.

These laws only hold good as long as the topsides in the immediate vicinity of the compass retain their dominant polarity due to their original direction of build in Great Britain: if in south magnetic latitudes a change of polarity takes place, the conditions of heeling correspond to such change.

The maximum disturbance on heeling in all these vessels is when their heads are (by disturbed compass) magnetic North or South, and this disturbance vanishes when the head is East or West. This law of disturbance may be thus explained: when the vessel's head is north or south on an even keel (by disturbed compass), the needle lies parallel to the topsides by their combined action, which neutralizes each other; on heeling, the nearest topside exercises its then dominant polarity at right angles to the direction of the needle, and hence the maximum error. With the ship's head east or west, whether on an even keel or heeling, either pole of the compass-needle points directly to the topsides, and is consequently unaffected except in a vertical plane.

As the amount of disturbance on heeling varies under the various conditions of direction of build, height of compass, and breadth of ship or distance of topsides, added to the prevailing permanent or inductive magnetic condition of the latter and the deck beams, each ship must have an individual character, to be determined only by experiment or observation at sea. There are, however, strong grounds for inferring that by a

* These principles have in their main features been confirmed by the experiments and investigations of the Secretary of the Liverpool Compass Committee,—Mr. RUNDELL,—to whom I am indebted for much valuable information on many questions of theoretical and practical value; but their simple illustration by a consideration of the appended diagrams, which, so far as I am aware, are novel in their application, will probably be found instructive and useful to the practical seaman.

judicious position of the compass, so as to ensure small errors while on an even keel, the errors arising from the ship's heel will be so proportionally reduced, as not practically to affect the navigation of the ship in the hands of a prudent seaman.

In concluding this Report, which in some of its details will, I trust, be found to narrow the grounds of inquiry in this interesting branch of science, so important in its practical relations to a maritime nation rapidly expanding its iron commercial navy, I beg leave to record the material assistance I have derived from the researches of the Astronomer Royal and ARCHIBALD SMITH, Esq., on the subject of a ship's magnetism. Without their skilful analysis and mathematical demonstrations, and much personal assistance rendered by the latter gentleman, I could not have approached the subject, and can therefore claim but little merit,—except that due to the labours of a lengthened computation, and some practical experience and close observation,—in the elucidation of whatever principles may be received as sound in practice and as additions to science.

I have the honour to be,

Sir,

Your obedient Servant,

FREDK. J. EVANS, Master R.N.

To Captain WASHINGTON, *R.N., F.R.S.,*
Hydrographer to the Admiralty.

Appendix.

No. I.

The Admiralty Standard Compass.

The chief points in the construction of this instrument are the following:—

1. The *bowl* is constructed of stout copper with the view to calm the vibrations of the needle, and the intersecting point of the axis of its gimbals is made to coincide with the point of suspension of the card, and also with the centre of the azimuth circle.

2. The *azimuth circle* is accurately graduated to minutes of arc, and may be used in addition on shore for surveying purposes: thus when accurate magnetic bearings are required, the zero of the circle may be adjusted to the magnetic north, shown by the card, and then clamped; any number of magnetic bearings may then be obtained round the circle: or by adjusting the zero of the circle to any given object and clamping the compass to its stand, the angles of objects round the horizon may be observed and read off to the nearest minute.

In observing Amplitudes and Azimuths, the bearings are read from the card without reference to the azimuth circle, the card being graduated to 20 minutes.

3. The *magnetic needles* employed are compound bars, formed of laminæ of that kind of steel (clock-spring) which has been ascertained by numerous experiments to be capable of receiving the greatest magnetic power. Each compass has two cards, A and J; the former is used at all times, except in stormy weather with much motion in the ship, when the heavy or J card is substituted.

Each *card* is fitted with four needles fixed vertically and equidistant on a light framework of brass screwed to the card; the pair of central needles are 7·3 inches long, and the pair of external ones 5·3 inches, the whole weight of the A card being 1525 grains*. The pivots for the needles are pointed with "native alloy," as being harder than steel, and not subject to corrosion by exposure to the atmosphere; the ruby cap of the card is worked to a form to suit these points.

4. The *impressions of the cards* are taken after the paper has been cemented to the mica plate forming the basis; distortions from shrinking are thus prevented and a more perfect centering attained.

Finally. The cards and needles are adjusted to the magnetic meridian at the Compass Observatory for Her Majesty's Navy at Woolwich, a place free from the local influence of iron. The various adjustments for centering, and the elimination of errors

* In order that a vibration communicated to a card about a diameter intermediate between the N. and S., and the E. and W. diameters, may not give rise to a "wabbling" motion, the moment of inertia of the card about these two diameters should be the same. It was shown by Mr. Archibald Smith that this is the case with any two parallel needles of uniform thickness forming chords of the same circle, if their extremities are separated by 60°; consequently, with any four such needles, if their extremities are separated by 30°; and the needles of the Admiralty Standard compasses have been uniformly so arranged.

due to displacement of sight-vanes, and prism, are also made at this observatory, the compass being afterwards supplied to Her Majesty's ships perfectly free from error.

No. II.

Table of Magnetic Elements (Terrestrial).

Place.	Inclination, or Dip.		Total Intensity, in 1840. Arbitrary scale. *b*	Horizontal intensity. Arbitrary scale. *c*	Scale adopted in Report.	On the authority of Mr. Airy. *d*	Scale adopted in Report.	By Gauss. *e*	Scale adopted in Report.
From Magnetic Survey of the British Islands:—	Year. ° ′	Year. ° ′							
Greenwich	1837 +69 17	1859 +68 25	1·372						
Greenhithe	„ +69 15	......	1·370			3·79			
Sheerness	„ +69 12	......	1·369			3·78			
Portsmouth	„ +69 2	......	1·370	=0·508	or 1·000	3·83	3·80 or 1·000	515	or 1·000
Portland	„ +69 7	......	1·372						
Plymouth	„ +69 16	......	1·375			3·82			
Holyhead	„ +70 52	......	1·395						
River Tagus	1840*a* +64 0	1858 +60 39*f*	1·35	=0·634	or 1·248	4·62	or 1·217	615	or 1·194
Malta	„ +52 0	......	1·21	„ 0·745	„ 1·467	5·74	„ 1·510	750	„ 1·456
Corfu	„ +55 0	1857 +55 42*g*	1·21	„ 0·694	„ 1·366	......		750	„ 1·456
Athens	„ +51 0	......	1·20	„ 0·755	„ 1·486	5·85	„ 1·539	740	„ 1·437
Constantinople	„ +54 0	......	1·22	„ 0·717	„ 1·411	5·63	„ 1·482	760	„ 1·495
River Danube, St. George's Mouth	„ +60 0	......	1·25	„ 0·625	„ 1·230	......		715	„ 1·388
Madeira	„ +60 30	1847 +59 42	1·34	„ 0·680	„ 1·339	......		660	„ 1·281
St. Vincent, Cape de Verd Islands	„ +45 0	......	1·18	„ 0·805	„ 1·585	......		805	„ 1·563
River Gambia	„ +38 30	......	1·15	„ 0·900	„ 1·771	......		820	„ 1·592
Isles de Los	„ +33 30	......	1·11	„ 0·925	„ 1·821	......		830	„ 1·611
Fernando Po	„ 0 0	......	0·95	„ 0·977	„ 1·923	......		875	„ 1·700
Ascension Island	„ + 0 30	......	0·90	„ 0·850	„ 1·673	......		830	„ 1·611
Tristan d'Acunha	„ −43 0	......	0·90	„ 0·658	„ 1·295	......		700	„ 1·361
Cape of Good Hope	„ −53 20	1857 −54 42*h*	0·98	„ 0·576	„ 1·148	4·46	„ 1·174	620	„ 1·204
St. Paul's (Indian Ocean)	„ −68 0	......	1·50	„ 0·562	„ 1·106	......		610	„ 1·185
Kurrachee	„ +28 15	......	1·16	„ 1·022	„ 2·012	......		1010	„ 1·961
Hong Kong	„ +30 20	1858 +31 26*h*	1·22	„ 1·041	„ 2·049	......		1000	„ 1·942
Canton	„ +31 30	1858 +32 35*h*	1·25	„ 1·040	„ 2·049	......		1000	„ 1·942
Shanghai	„ +44 0	1857 +45 18*h*	1·31	„ 0·921	„ 1·813	......		925	„ 1·796
Apia, Upolu I. (Pacific Ocean)	„ −35 30	......	1·30	„ 1·058	„ 2·083	......		980	„ 1·903
Sydney, New South Wales	„ −62 45	1849 −62 45	1·67	„ 0·765	„ 1·506	......		870	„ 1·689
Port Nicholson, New Zealand	„ −65 0	1850 −64 52	1·66	„ 0·702	„ 1·382	......		855	„ 1·660
King George's Sound	„ −65 0	1845 −65 12	1·69	„ 0·714	„ 1·406	......		765	„ 1·485
Swan River, Australia	„ −62 30	1846 −63 6	1·64	„ 0·757	„ 1·490	......		785	„ 1·524
Sydney, Cape Breton Island	„ +76 30	......	1·68	„ 0·392	„ 0·772	......		370	„ 0·719
St. John's, Newfoundland	„ +76 0	......	1·63	„ 0·394	„ 0·776	......		355	„ 0·689
Halifax, Nova Scotia	„ +75 45	1847 +75 37	1·70	„ 0·418	„ 0·823	......		400	„ 0·777
Penetanguishine, Lake Huron	„ +76 0	1844 +76 20	1·84	„ 0·445	„ 0·876	......		395	„ 0·767
Antigua	„ +50 0	......	1·38	„ 0·887	„ 1·746	......		840	„ 1·631
Rio de Janeiro	„ −12 30	1857 −11 21*h*	0·86	„ 0·841	„ 1·675	6·49	„ 1·708	860	„ 1·670
Monte Video	„ −35 0	1853 −32 7*i*	1·06	„ 0·898	„ 1·768	6·16*i*	„ 1·602	835	„ 1·621
Callao	„ − 7 0	......	1·00	„ 0·997	„ 1·963	......		1000	„ 1·942
Valparaiso	„ −38 30	1857 −35 37*k*	1·17	„ 0·934	„ 1·838	7·17	„ 1·887	865	„ 1·680
Sandwich Islands, Honolulu	„ +40 30	1857 +42 0*k*	1·10	„ 0·817	„ 1·628	......		890	„ 1·728
Vancouver Island, Esquimalt	„ +72 0	1858 +71 55*k*	1·70	„ 0·528	„ 1·040	......		500	„ 0·971
„ Naniamo	„ +72 20	......	1·70	„ 0·516	„ 1·016	......		495	„ 0·961

a, *b* On the authority of General SABINE, from KEITH JOHNSTON'S Physical Atlas, Second Edition, "Terrestrial Magnetism."

c Computed from the formula $X = R\cos\theta$, in which R denotes the total intensity, X its horizontal component, and θ the dip.

d Philosophical Transactions for 1856, Mr. AIRY "On the Observed Deviations of the Compass in Wood-built and Iron-built Ships.'

e From the Atlas des Erdmagnetismus of GAUSS. Leipzig, 1840.

f Dr. J. LAMONT, "Erdmagnetismus an verschiedenen Puncten des Südwestlichen Europa." Munich, 1858.

g Dr. F. SCHAUB, "Magnetische Beobachtungen im Östlichen Theile des Mittelmeeres." Trieste, 1858.

h From Captain SHADWELL, R.N., Her Majesty's Ship Highflyer.

i From Lieutenant GILLISS, United States Navy.

k From Captain G. H. RICHARDS, R.N., Her Majesty's Surveying Ship Plumper.

TABLE I.—Iron-built Ships, Her Majesty's Navy.

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients. A.	D.	E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.
Feb. 25, 1855.	Portsmouth	HIMALAYA, 3453	+0° 46′	+3° 51′	+0° 21′	−15° 58′	−0·2751	− 0° 33′	−0·0096
Nov. 21, 1856.	Plymouth		+0 30	+2 48	+0 32	−14 3	−0·2428	− 0 23	−0·0067
July 4, 1859.	Plymouth		+0 20	+3 18	−0 10	−14 5	−0·2433	+ 2 53	0·0503
Sept. 21, 1855.	Sheerness	URGENT, 1981	+0 4	+2 58	+0 10	−12 20	−0·2136	+ 0 58	0·0169
Nov. 7, 1855.	*Malta*		+0 54	+3 6	−0 34	− 7 10	−0·1247	− 0 31	−0·0090
June 25, 1856.	Plymouth		−0 20	+2 45	−0 5	−10 23	−0·1802	+ 1 51	0·0323
Oct. 29, 1857.	Portsmouth		+0 32	+2 22	−0 11	− 8 43	−0·1515	+ 3 34	0·0622
Oct. 11, 1859.	Portsmouth		+0 38	+2 12	−0 9	− 8 32	−0·1484	+ 1 37	0·0282
Feb. 19, 1852.	Portsmouth	SIMOOM*, 1980	+0 11	+3 57	−0 9	+20 5	0·3434	− 7 15	−0·1262
Sept. 28, 1852.	Portsmouth		−0 9	+4 33	−0 19	+20 7	0·3439	− 7 18	−0·1271
Feb. 1853.	*Cape of Good Hope*		−1 47	+4 13	+0 22	+13 6	0·2266	− 2 23	−0·0416
Jan. 13, 1857.	Portsmouth		−0 6	+3 50	−0 10	+18 51	0·3231	− 1 35	−0·0276
Nov. 5, 1859.	Portsmouth		+0 23	+3 25	−0 50	+18 23	0·3154	+ 1 14	0·0215
June 14, 1855.	Portsmouth	PERSEVERANCE, 1967	+0 4	+3 18	+0 30	− 6 39	−0·1158	+ 1 33	0·0270
Mar. 13, 1856.	Portsmouth		+0 52	+2 53	+0 20	− 7 32	−0·1311	+ 1 45	0·0305
Aug. 10, 1858.	Portsmouth		+0 10	+1 51	+0 5	− 5 19	−0·0926	+ 0 10	0·0029
Oct. 8, 1859.	Portsmouth		+0 30	+2 0	−0 10	− 5 5	−0·0886	+ 2 25	0·0422
Aug. 31, 1855.	Greenhithe	TRANSIT, 2587	−0 12	+3 12	−0 8	+13 40	0·2363	+ 0 13	0·0038
Mar. 17, 1857.	Portsmouth		−0 44	+3 12	−0 2	+10 47	0·1871	+ 2 49	0·0491
May 4, 1857.	Portsmouth	ASSISTANCE, 1820	−0 8	+3 35	+0 1	−13 0	−0·2249	+11 49	0·2048
May 11, 1857.	Portsmouth	†	+0 12	+3 36	+0 19	− 9 28	−0·1645	+11 29	0·1991
Feb. 24, 1858.	*Canton River, China*		+0 23	+3 24	+0 30	− 3 47	−0·0660	+ 6 42	0·1167
May 9, 1857.	Portsmouth	ADVENTURE, 1794	−0 45	+3 40	−0 7	− 9 52	−0·1714	+14 38	0·2526
1858.	*Whampoa, China*		−0 20	+3 0	−0 27	− 4 0	−0·0697	+ 7 38	0·1328
Feb. 21, 1851.	Sheerness	VULCAN, 1764 F.U.‡	+0 38	+3 20	+0 20	− 9 15	−0·1607	+ 1 55	0·0334
		F.D.	+0 29	+3 0	+0 11	− 8 37	−0·1498	+ 2 12	0·0384
Sept. 30, 1851.	Portsmouth		+0 15	+3 0	+0 18	− 9 25	−0·1636	+ 2 18	0·0401
July 1, 1852.	Portsmouth		−0 13	+3 37	−0 44	− 8 47	−0·1527	+ 0 43	0·0125
Nov. 19, 1852.	*Sydney, New South Wales*	*F.D.*	−0 16	+2 3	+0 55	−13 39	−0·2360	+ 2 43	0·0474
Feb. 1853.	*Cape of Good Hope*		+1 8	+4 15	+0 51	−16 3	−0·2765	+ 1 19	0·0230
May 26, 1853.	Portsmouth	F.U.	+0 31	+3 5	+0 16	− 8 28	−0·1472	+ 3 11	0·0555
June 19, 1854.	Portsmouth	F.U.	+0 16	+3 29	−0 53	− 1 40	−0·0291	+ 3 6	0·0541

* Head built S. 30° W. magnetic. Keel at an angle of 2° 15′ from horizontal plane.

† Standard compass changed in its elevation from deck 1 foot 11 inches; diminishing ship's force one-seventh.

‡ F.U. Funnel up. F.D. Funnel down.

Table I.—Iron-built Ships, Her Majesty's Navy.

Resultant of B and C, or ship's Total force.		Magnetic elements.		Position of standard compass.			Beams.	Horse-power and engines.	Where built.	Date of launching.
Direction.	Amount.	Horizontal force.	Dip, and nat. tang.	From funnel. ft. in.	From tafrail. ft. in.	Height from deck. ft. in.				
182°	0·275	1·000	+68° 25′ 2·53	113 0	62 0	8 4	Iron.	700, Screw.	Blackwall.	1854.
181½	0·243	1·000	+68 25 2·53	113 0	62 0	8 4				
168½	0·248	1·000	+68 25 2·53	113 0	62 0	8 4				
175½	0·215	1·000	+68 25 2·53	91 0	72 0	5 0	Poop-deck, wood.	450, Screw.	Blackwall (Mare and Co.).	3rd April, 1855.
184	0·125 0·189	1·510	+52 0 1·28	91 0	72 0	5 0				
170	0·183	1·000	+68 25 2·53	91 0	72 0	5 0				
157½	0·163	1·000	+68 25 2·53	91 0	72 0	5 0				
169½	0·151	1·000	+68 25 2·53	91 0	72 0	5 0				
340	0·367	1·000	+68 25 2·53	55 4	33 10	4 2½	Poop-deck, wood.	350, Screw.	Glasgow (R. Napier).	24th May, 1849.
340	0·367	1·000	+68 25 2·53	55 4	33 10	4 2½				
350	0·231 0·270	1·174	−54 42 − 1·41	55 4	33 10	4 2½				
355	0·326	1·000	+68 25 2·53	55 4	33 10	4 2½				
4	0·316	1·000	+68 25 2·53	56 4	31 6	4 6				
167	0·119	1·000	+68 25 2·53	97 0	71 0	4 3	Poop-deck, wood.	360, Screw.	Blackwall (Mare and Co.).	13th July, 1854.
167	0·134	1·000	+68 25 2·53	97 0	71 0	4 3				
178	0·093	1·000	+68 25 2·53	88 0	67 0	5 4				
154½	0·098	1·000	+68 25 2·53	88 0	67 0	5 4				
1	0·236	1·000	+68 25 2·53	105 0	72 0	4 6	Poop-deck, wood.	500, Screw.	Blackwall (Mare and Co.).	20th Mar. 1855.
15	0·194	1·000	+68 25 2·53	105 0	72 0	4 6				
138	0·304	1·000	+68 25 2·53	122 0	30 0	4 5	Iron.	400, Screw.	Birkenhead (Laird).	5th April, 1855.
130	0·259	1·000	+68 25 2·53	122 0	30 0	6 4				
120	0·134 0·274	2·049	+32 35 0·63	122 0	30 0	6 4				
124	0·305	1·000	+68 25 2·53	125 0	30 0	6 4	Iron.	400, Screw.	Birkenhead (Laird).	17th Feb. 1855.
118	0·150 0·307	2·049	+31 30 0·61	125 0	30 0	6 4				
168½	0·163	1·000	+68 30 2·54	27 10	49 8	5 0	Poop-deck, wood.	350, Screw.	Blackwall (Ditchburn and Mare).	27th Jan. 1849.
166	0·154	1·000								
166½	0·168	1·000	+68 30 2·54	27 10	49 8	5 0				
175½	0·153	1·000	+68 30 2·54	27 10	49 8	5 0				
168½	0·241 0·363	1·506	−62 45 − 1·94	27 10	49 8	5 0				
175	0·278 0·326	1·174	−54 42 − 1·41	27 10	49 8	5 0				
160	0·157	1·000	+68 30 2·54	27 10	49 8	5 0				
118	0·062	1·000	+68 30 2·54	27 10	49 8	5 0				

Table I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Date.	Place of observation.	Ship's name and tonnage.	Permanent coefficients. A.	D.	E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.
Apr. 17, 1856.	Portsmouth	Vulcan, 1764 *continued.*	−0° 9′	+3° 7′	−0° 3′	− 7° 37′	−0·1325	+ 3° 33′	0·0619
Nov. 6, 1856.	Sheerness	F.D.	+0 27	+1 55	+0 21	− 5 4	−0·0883	+ 3 50	0 0668
Sept. 4, 1857.	Portsmouth	F.U.	+0 30	+2 56	−0 3	− 1 58	−0·0343	+ 4 58	0·0866
		F.D.	+0 13	+2 55	−0 16	+ 0 51	0·0148	+ 5 11	0·0903
Aug. 16, 1859.	Portsmouth	F.U.	+0 40	+2 48	+0 28	− 4 20	−0·0756	+ 9 37	0·1670
		F.D.	+0 36	+2 51	+0 5	− 1 34	−0·0273	+ 9 25	0·1636
Oct. 22, 1851.	Sheerness	Megæra, 1395 F.D.	−0 15	+1 46	+0 32	−12 43	−0·2201	− 2 5	−0·0363
		F.U.	+0 3	+2 32	−0 8	−13 5	−0·2264	− 3 12	−0·0558
Sept. 11, 1852.	Sheerness		−0 24	+1 15	+0 29	−11 52	−0·2056	+ 6 52	0·1196
Dec. 8, 1853.	*Antigua*		+0 5	+1 36	−0 5	− 5 46	−0·1005	+ 3 58	0·0692
Jan. 23, 1857.	Portsmouth		+0 46	+1 48	−0 23	−12 1	−0·2082	+ 3 51	0·0671
Jan. 20, 1847.	Greenhithe	Birkenhead, 1405	+0 18	+2 53	−0 11	−13 51	−0·2394	− 6 27	−0·1123
Feb. 19, 1847.	Portsmouth		−0 14	+2 44	+0 25	−13 51	−0 2394	− 6 39	−0·1158
Mar. 20, 1848.	Portsmouth		−0 29	+2 48	+0 23	−13 30	−0·2334	− 6 32	−0·1138
1850.	Portsmouth		−0 30	+2 13	+0 22	−13 36	−0·2351	− 6 54	−0·1201
Feb. 17, 1851.	Portsmouth		−0 33	+2 12	+0 27	−13 51	−0·2394	− 6 48	−0·1184
Aug. 10, 1846.	Greenhithe	Trident, 850	+0 38	+4 3	+0 45	+20 8	0·3442	+ 1 13	0·0212
1847.	*Malta*		+0 25	+3 46	+0 30	+13 38	0·2357	− 2 0	−0·0349
May 23, 1848.	Greenhithe		+0 37	+3 52	+0 21	+21 1	0·3586	− 0 13	−0·0038
Oct. 17, 1849.	Plymouth		+0 25	+3 31	−0 6	+18 26	0·3162	− 0 2	−0·0006
Sept. 8, 1852.	Greenhithe		+0 5	+3 38	+0 27	+19 41	0·3368	− 2 37	−0·0456
Nov. 7, 1852.	*Rio Janeiro*		−0 10	+4 3	−0 9	+12 18	0·2130	− 1 52	−0·0326
Dec. 23, 1856.	Greenhithe		−0 11	+3 43	+0 10	+21 50	0·3719	− 3 26	−0·0599
May 1857.	*Ascension Island*		+1 3	+2 50	+1 21	+12 15	0·2122	− 4 2	−0·0703
November 1857.	*Cape of Good Hope*		−0 22	+2 55	−0 6	+16 27	0·2832	− 1 35	−0·0276
Oct. 31, 1859.	Greenhithe		−0 8	+3 26	+0 34	+18 40	0·3201	+ 0 50	0·0145
Nov. 19, 1855.	Greenhithe	Hesper, 808	+1 13	+3 10	+0 36	− 0 7	−0·0020	− 3 17	−0·0573
Oct. 11, 1856.	Greenhithe		+0 12	+3 0	+0 38	+ 1 28	0·0256	− 0 27	−0·0078
May 1, 1857.	Greenhithe		+0 12	+3 17	+0 21	+ 2 22	0·0413	+ 0 23	0·0067
June 8, 1848.	Greenhithe	Caradoc, 676	+0 43	+3 13	+0 18	−12 33	−0·2173	− 4 15	−0·0741
May 21, 1852.	*Malta*		+0 31	+2 15	−0 17	− 9 42	−0·1685	− 1 33	−0·0270
Nov. 4, 1855.	Greenhithe		−0 25	+2 6	+0 12	−10 54	−0·1891	− 2 8	−0·0372

Table I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Resultant of B and C, or ship's total force.		Magnetic elements.		Position of standard compass.			Beams.	Horse-power and engines.	Where built.	Date of launching.
Direction.	Amount.	Horizontal force.	Dip, and nat. tang.	From funnel. ft. in.	From tafrail. ft. in.	Height from deck. ft. in.				
155°	0·146	1·000	+68° 30′ 2·54	26 4	49 8	5 2	Wood, on poop-deck.	350, Screw.	Blackwall (Ditchburn and Mare).	27th Jan. 1849.
143	0·111	1·000	+68 30 2·54	26 4	49 8	5 2				
111	0·093	1·000	+68 30 2·54	26 4	49 8	5 2				
81	0·092	1·000	+68 30 2·54	26 4	49 8	5 2				
114	0·183	1·000	+68 30 2·54	26 5	50 4	5 4				
100	0·166	1·000	+68 30 2·54	26 5	50 4	5 4				
189½	0·223	1·000	+68 30 2·54	78 4	38 0	3 9	Wood, on poop-deck.	350, Screw.	Millwall (Fairbairn).	22nd May, 1849.
193½	0·232	1·000	+68 30 2·54	78 4	38 0	3 9				
150	0·238	1·000	+68 30 2·54	78 4	38 0	3 9				
145	0·122 0·213	1·746	+50 0 1·19	78 4	38 0	3 9				
162	0·219	1·000	+68 30 2·54	77 0	39 0	4 0				
205	0·264	1·000	+68 45 2·57	52 0	38 0	4 1	Wood, on poop-deck.	556, Paddle.	Birkenhead (Laird).	30th Dec. 1845.
206	0·265	1·000	+68 45 2·57	52 0	38 0	4 1				
206	0·260	1·000	+68 45 2·57	52 0	38 0	4 1				
207	0·264	1·000	+68 45 2·57	52 0	38 0	4 1				
206	0·267	1·000	+68 45 2·57	52 0	38 0	4 1				
3	0·345	1·000	+68 45 2·57	36 6	35 0	5 0	Wood, on quarter-deck. Iron in fore-part of ship.	350, Paddle.	Blackwall (Ditchburn and Mare).	16th Dec. 1845.
352	0·238 0·359	1·510	+52 0 1·28	36 6	35 0	5 0				
359½	0·359	1·000	+68 45 2·57	36 6	35 0	5 0				
360	0·316	1·000	+68 45 2·57	36 6	35 0	5 0				
352½	0·342	1·000	+68 45 2·57	36 6	35 0	5 0				
351	0·216 0·368	1·708	−11 21 − 0·20	36 6	35 0	5 0				
351	0·376	1·000	+68 30 2·54	36 6	35 0	5 1				
341½	0·223 0·373	1·673	+ 0 30 0·01	36 6	35 0	5 1				
354½	0·285 0·333	1·174	−54 42 − 1·41	36 6	35 0	5 1				
2½	0·320	1·000	+68 25 2·53	36 6	35 0	5 1				
272	0·057	1·000	+68 30 2·54	49 6†	102 0	11 1	Iron.	120, Screw.		
344	0·026	1·000	+68 30 2·54	49 6	102 0	11 1				
9	0·042	1·000	+68 30 2·54	49 6	102 0	11 1				
199	0·230	1·000	+68 40 2·56	60 0	40 0	7 0	Wood.	350, Paddle.	Blackwall (Ditchburn and Mare).	3rd July, 1847.
189	0·171 0·258	1·511	+52 0 1·28	60 0	40 0	7 0				
191	0·193	1·000	+68 30 2·54	60 0	40 0	7 0				

† Compass before the funnel, on bridge.

TABLE I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients.			Coefficient	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient	Ship's force to Starboard. Earth's horizontal force =1·000.
			A.	D.	E.	B.		C.	
April 21, 1857.	*Malta*	CARADOC, 676 *continued.*	+0° 49′	+2° 13′	+0° 10′	− 8° 36′	−0·1495	− 1° 38′	−0·0285
Dec. 13, 1858.	*Malta*		+1 27	+2 52	−0 20	− 8 38	−0·1501	− 3 6	−0·0541
Sept. 8, 1847.	Greenhithe	ANTELOPE, 650	+0 14	+2 58	+0 10	− 6 42	−0·1167	+ 0 59	0·0172
Mar. 24, 1852.	Greenhithe		+0 2	+2 30	+0 45	− 6 46	−0·1178	− 1 1	−0·0177
Sept. 8, 1853.	Portsmouth		−0 22	+2 19	+0 17	− 8 23	−0·1460	− 3 41	−0·0642
Jan. 8, 1857.	Greenhithe		+0 29	+3 4	+0 23	− 3 8	−0·0547	− 5 18	−0·0924
Mar. 1, 1848.	Greenhithe	TRITON, 654	+0 40	+4 2	+0 32	−11 56	−0·2068	+ 0 26	0·0076
June 23, 1852.	Greenhithe		−0 3	+3 8	+0 23	− 7 47	−0·1354	− 2 32	−0·0442
Sept. 18, 1852.	*Corfu*		+1 10	+3 20	−0 2	− 5 36	−0·0976	− 2 4	−0·0361
Nov. 12, 1857.	Greenhithe		+0 25	+2 37	+0 39	− 8 37	−0·1498	− 5 34	−0·0970
Dec. 3, 1858.	*Fernando Po*		−1 0	+3 21	−0 5	− 5 36	−0·0976	− 0 4	−0·0012
Nov. 16, 1847.	Portsmouth	OBERON, 649	+1 35	+3 23	+0 13	+ 6 18	0·1097	−14 2	−0·2425
July 26, 1851.	Portsmouth		−0 20	+2 16	+0 20	+ 5 43	0·0996	−11 57	−0·2071
Nov. 28, 1856.	*Malta*		0 0	+2 43	−0 27	+ 3 27	0·0602	− 6 47	−0·1181
Aug. 10, 1858.	Greenhithe		−0 5	+3 27	+0 8	+ 8 15	0·1435	− 6 16	−0·1092
Dec. 30, 1858.	*Monte Video*		+2 11	+2 50	−0 38	+ 3 29	0·0608	− 5 23	−0·0938
July 19, 1854.	Greenhithe	INDUSTRY, 638	−0 34	+2 55	−0 32	+13 55	0·2405	+ 3 12	0·0558
Jan. 10, 1856.	*Malta*		−1 10	+3 0	−0 23	+ 9 9	0·1590	− 0 9	−0·0026
Sept. 30, 1856.	Greenhithe		−0 45	+2 45	−0 23	+14 27	0·2495	+ 3 13	0·0561
Jan. 13, 1858.	Greenhithe		+0 26	+2 31	+0 22	+13 17	0·2298	− 0 37	−0·0107
Aug. 25, 1858.	Greenhithe		+0 18	+2 23	−0 9	+10 25	0·1808	− 1 11	−0·0206
July 19, 1859.	Greenhithe		+0 13	+2 40	−0 13	+10 43	0·1859	+ 0 4	0·0011
Sept. 4, 1854.	Greenhithe*	SUPPLY, 638	+0 29	+3 40	−0 4	−16 41	−0·2871	+12 2	0·2085
April 19, 1859.	Greenhithe		−0 10	+3 7	−0 3	−15 1	−0·2591	− 0 36	−0·0105
Sept. 19, 1859.	Greenhithe		−0 35	+2 23	−1 20	−14 3	−0·2428	− 0 53	−0·0154
Jan. 14, 1860.	Greenhithe		+0 41	+2 15	−0 47	−15 13	−0·2625	− 0 5	−0·0014
Mar. 30, 1855.	Plymouth	WESER†, 590	−0 07	+3 50	−0 39	−11 59	−0·2076	+ 1 16	0·0221
July 28, 1857.	*St. Geo. Mouth, R. Danube*		+0 9	+4 11	+0 38	− 6 33	−0·1141	− 4 47	−0·0834
Nov. 17, 1859.	Greenhithe		+0 9	+3 35	+0 23	+ 1 0	0·0174	+ 3 52	0·0674
Mar. 29, 1855.	Plymouth	RECRUIT† (Steam-vessel), 590.	+0 1	+4 7	−0 16	−13 47	−0·2382	− 0 53	−0·0154

* These observations were made with a common prismatic compass: the coefficients have been computed both directly from the observations, and from a probable curve graphically drawn through the observations: the results accord closely.

† These vessels were received from the Prussian Government in 1854.

Table I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Resultant of B and C, or ship's Total force.		Magnetic elements.		Position of standard compass.			Beams.	Horse-power and engines.	Where built.	Date of launching.
Direction.	Amount.	Horizontal force.	Dip, and nat. tang.	From funnel.	From taffrail.	Height from deck.				
				ft. in.	ft. in.	ft. in.				
191°	0·152 0·229	1·510	+52° 0′ 1·28	60 0	40 0	7 0	Wood.	350, Paddle.	Blackwall (Ditchburn and Mare).	July 3, 1847.
200	0·160 0·242	1·510	+52 0 1·28	60 0	40 0	7 0				
171½	0·118	1·000	+68 40 2·56	56 0	21 0	4 7½	Wood.	260, Paddle.	Blackwall (Ditchburn and Mare).	July 25, 1846.
188½	0·119	1·000	+68 40 2·56	56 0	21 0	4 7½				
203½	0·161	1·000	+68 40 2·56	56 0	21 0	4 7½				
239	0·106	1·000	+68 40 2·56	37 0	41 0	4 8				
178	0·207	1·000	+68 40 2·56	32 8	40 7	4 9	Wood.	260, Paddle.	Blackwall (Wigram).	Oct. 24, 1846.
198	0·142	1·000	+68 40 2·56	32 8	40 7	4 9				
200	0·104 0·142	1·366	+55 30 1·46	32 8	40 7	4 9				
213	0·178	1·000	+68 25 2·53	35 0	36 0	4 9				
181	0·098 0·188	1·923	0 0	35 0	36 0	4 9				
294	0·266	1·000	+68 40 2·56	52 4	21 2	4 9½	Wood.	260, Paddle.	Deptford (Rennie).	January 2, 1847.
295	0·230	1·000	+68 40 2·56	52 4	21 2	4 9½				
297	0·133 0·201	1·510	+52 0 1·28	52 4	21 2	4 9½				
323	0·180	1·000	+68 30 2·54	41 10	30 3	4 10				
303	0·112 0·179	1·602	−32 0 0·62	41 10	30 3	4 10				
13	0·247	1·000	+68 25 2·53	73 5	18 11	4 11	Iron.	80, Screw.	Blackwall (Mare and Co.).	1854.
359	0·159 0·240	1·510	+52 0 1·28	73 5	18 11	4 11				
13	0·256	1·000	+68 25 2·53	73 5	18 11	4 11				
357½	0·230	1·000	+68 25 2·53	73 5	18 11	4 11				
353½	0·182	1·000	+68 25 2·53	73 5	18 11	4 11				
360½	0·186	1·000	+68 25 2·53	73 5	18 11	4 11				
144	0·354	1·000	+68 25 2·53	70 0	18 0	5 0	Iron.	80, Screw.	Blackwall (Mare and Co.).	June 3, 1854.
182	0·259	1·000	+68 25 2·53	69 6	18 2	5 2				
183½	0·243	1·000	+68 25 2·53	69 6	18 2	5 2				
180¼	0·262	1·000	+68 25 2·53	69 6	18 2	5 2				
174	0·209	1·000	+68 30 2·54	8 10‡	66 0	11 7	Wood.	160, Paddle.		
216	0·141 0·173	1·230	+60 0 1·73	8 10‡	66 0	11 7				
75½	0·069	1·000	+68 25 2·53	42 4	30 0	4 6½				
184½	0·239	1·000	+68 25 2·53	8 10‡	66 0	11 7	Wood.	160, Paddle.		

‡ Compass placed on the bridge, nearly midway between two funnels: the distance is given from the nearest funnel.

TABLE I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients. A.	Permanent coefficients. D.	Permanent coefficients. E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.
April 26, 1848.	Portsmouth	SHARPSHOOTER, 503...	−0° 7′	+4° 32′	+0° 14′	− 7° 17′	−0·1268	+ 0° 24′	0·0070
		Heeled 7° to starboard.	+0 3	+4 13	−0 28	− 7 52	−0·1369	− 0 23	−0·0067
April 1, 1850.	Portsmouth	....	+0 16	+3 53	+0 5	− 6 1	−0·1048	+ 0 2	0·0006
Nov. 12, 1852.	Portsmouth	....	−0 33	+3 17	−0 21	−16 17	−0·2804	− 0 5	−0·0014
Feb. 8, 1853.	*Rio de Janeiro*	....	+0 20	+3 2	−0 2	− 8 25	−0·1464	− 1 25	−0·0247
Dec. 28, 1857.	*Portsmouth*	....	+0 10	+4 12	+0 3	−12 44	−0·2204	+ 4 40	0·0814
Aug. 31, 1859.	*Isles de Los, Africa*	....	−0 45	+3 35	+1 7	− 6 58	−0·1213	+ 0 56	0·0163
Aug. 28, 1846.	Greenhithe	RECRUIT (Sailing Brig), 462.	−0 30	+1 30	−0 33	+ 3 7	0·0544	+ 6 36	0·1149
Aug. 28, 1846.	Greenhithe	....	−0 41	+1 7	−1 3	+12 50	0·2221	+ 5 12	0·0906
		Heeled 8° to port	+2 18	+1 57	−0 8	+12 48	0·2215	+ 1 30	0·0262
Nov. 1846.	Plymouth		+1 51	+2 19	−0 40	+12 41	0·2196	+ 7 27	0·1297
		Heeled 8° to starboard.	+0 21	+2 5	−0 13	+14 10	0·2447	+14 25	0·2490
Oct. 18, 1855.	Greenhithe	BARON VON HUMBOLDT, *afterwards named*	−0 18	+5 10	+0 24	+16 33	0·2848	− 5 47	−0·1008
Dec. 15, 1855.	Greenhithe	BUFFALO, 440............	+0 3	+3 4	+0 5	−16 46	−0·2885	+ 0 35	0·0102
Dec. 24, 1856.	Greenhithe	....	+0 2	+3 2	+0 6	−19 6	−0·3272	− 0 47	−0·0137
Feb. 26, 1858.	Greenhithe	....	+0 39	+2 35	+0 23	+13 12	0·2283	+ 1 33	0·0270
Mar. 17, 1846.	Greenhithe	MYRMIDON, 374.........	−0 16	+3 23	+0 3	+15 18	0·2639	+ 2 58	0·0517
Aug. 11, 1851.	Woolwich	....	+0 46	+3 9	−0 28	+19 23	0·3319	− 5 31	−0·0961
July 2, 1855.	Portsmouth	....	+0 21	+2 45	+0 12	+17 7	0·2943	+ 0 28	0·0081
Sept. 8, 1855.	Portsmouth	WYE, 700.........	+0 7	+3 24	+0 41	− 1 40	−0·0291	+12 53	0·2230
Sept. 6, 1845.	Plymouth	BLOODHOUND, 378.........	+0 23	+3 40	+0 10	+14 37	0·2523	− 2 12	−0·0384
1846.	*Constantinople*	....	+0 7	+3 22	−0 51	+10 40	0·1851	− 2 31	−0·0439
1846.	*Athens* (*Piræus*)	....	+0 25	+3 59	−0 6	+ 9 0	0·1564	− 2 32	−0·0442
		Heeled 8° to port	+0 5	+3 21	+0 4	+11 43	0·2031	− 4 40	−0·0814
May 11, 1847.	Greenhithe		+0 32	+3 5	+0 20	+11 57	0·2071	− 1 48	−0·0314
		Heeled 8° to starboard.	−0 17	+2 45	−0 20	+11 33	0·2002	+ 1 15	0·0218
Feb. 12, 1851.	Plymouth	....	−2 39	+2 35	+0 4	+12 20	0·2136	− 2 49	−0·0491
Sept. 7, 1855.	Greenhithe	....	+0 13	+2 31	+0 26	+11 46	0·2039	− 2 7	−0·0369
Mar. 20, 1845.	Greenhithe	JACKAL, 340.........	−0 25	+4 57	−0 25	+24 7	0·4086	+ 0 45	0·0131
July 16, 1845.	Plymouth	....	+0 15	+4 13	−0 5	+16 38	0·2862	− 1 52	−0·0326
1846.	*Athens* (*Piræus*)	....	+0 15	+3 52	−0 7	+10 15	0·1779	− 0 47	−0·0137

TABLE I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Resultant of B and C, or ship's Total force.		Magnetic elements.		Position of standard compass.			Beams.	Horse-power and engines.	Where built.	Date of launching.
Direction.	Amount.	Horizontal force.	Dip, and nat. tang.	From funnel.	From tafrail.	Height from deck.				
				ft. in.	ft. in.	ft. in.				
177°	0·126	1·000	+68° 25′ 2·53	43 6	44 6	4 8½	Wood.	202, Screw.	Blackwall (Ditchburn and Mare).	July 25, 1846.
183	0·137			43 6	44 6	4 8½				
180	0·105	1·000	+68 25 2·53	46 0	43 0	4 8½				
180	0·280	1·000	+68 25 2·53	57 4	28 11	5 8				
189	0·148 0·253	1·708	−11 21 − 0·20	57 4	28 11	5 8				
160	0·235	1·000	+68 25 2·53	57 4	28 11	6 2				
172	0·122 0·222	1·821	+33 30 1·51	57 4	28 11	6 2				
65	0·127	1·000	+68 25 2·53		9 2		Wood beams. Iron bulwarks.	*Sailing vessel.*	Blackwall (Ditchburn and Mare).	1846.
22	0·240	1·000	+68 25 2·53		16 4					
7	0·223					1 7†				
30½	0·255	1·000	+68 25 2·53		16 4	8 10‡				
46	0·349									
339	0·302	1·000	+68 25 2·53	44 0	12 0	4 8	Iron.	60, Screw.		
178	0·289	1·000	+68 25 2·53	6 6*	63 0	11 0				
182	0·328	1·000	+68 25 2·53	6 6*	63 0	11 0				
7	0·230	1·000	+68 25 2·53	34 0	26 0	4 9				
11	0·269	1·000	+68 30 2·54	37 6	23 8	5 6	Iron.	150, Screw.	Blackwall (Ditchburn and Mare).	February 1845.
344	0·346	1·000	+68 30 2·54	37 6	23 8	5 6				
1½	0·294	1·000	+68 30 2·54	37 6	23 8	5 6				
97½	0·226	1·000	+68 30 2·54	51 3	47 8	4 4	Iron.	Screw.		
351	0·256	1·000	+68 40 2·56	41 6	14 0	5 6	Iron.	150, Paddle.	Glasgow (R. Napier).	9th Jan. 1845.
347	0·190 0·281	1·482	+54 0 1·38	41 6	14 0	5 6				
344	0·162 0·249	1·000	+68 40 2·56	41 6	14 0	5 6				
338	0·219			41 6	14 0	5 6				
351	0·209	1·000	+68 40 2·56	41 6	14 0	5 6				
6	0·202			41 6	14 0	5 6				
347	0·219	1·000	+68 40 2·56	42 3	15 10	5 6				
350	0·207	1·000	+68 40 2·56	42 3	15 10	5 6				
2	0·409	1·000	+68 40 2·56	25 6	32 6	7 0	Iron.	150, Paddle.	Glasgow (R. Napier).	28th Oct. 1844.
353	0·288	1·000	+68 40 2·56	42 2	16 8	7 0				
355½	0·178 0·274	1·539	+51 0 1·23	42 2	16 8	7 0				

* In these examples the compass was placed on the bridge *before* the funnel.

† Above the level of iron bulwarks.

‡ Distance from iron bulwarks.

Table I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients. A.	Permanent coefficients. D.	Permanent coefficients. E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.
			° ′	° ′	° ′	° ′		° ′	
1847.	*River Tagus*	Jackal, 340 *continued.*	−0 13	+4 2	+0 22	+12 15	0·2122	− 1 39	−0·0288
Jan. 26, 1849.	Portsmouth		+0 18	+2 58	+0 38	+14 49	0·2557	− 4 12	−0·0732
Aug. 5, 1854.	Greenhithe		+0 10	+3 8	−0 35	+15 38	0·2695	− 9 31	−0·1653
May 10, 1859.	Greenhithe		+0 25	+3 1	+0 33	+14 10	0·2447	− 5 29	−0 0955
Jan. 30, 1846.	Greenhithe	Harpy, 343	−0 15	+2 54	+0 48	+ 7 3	0·1227	+ 2 19	0·0404
May 1, 1854.	Falmouth		−1 2	+2 41	−0 30	+ 8 43	0·1515	+ 0 49	0·0143
Dec. 23, 1857.	*Malta*		−0 15	+2 50	−0 18	+ 6 14	0·1086	− 0 53	−0·0154
Mar. 6, 1860.	Greenhithe		+0 48	+2 32	−0 4	+11 12	0·1942	− 1 25	−0·0247
1845.	Greenhithe	Lizard, 340	−0 3	+3 49	+0 19	+13 31	0·2337	− 2 3	−0·0358
April 7, 1853.	Sheerness		+0 34	+2 59	+0 53	+10 49	0·1877	+ 0 36	0·0105
Feb. 8, 1858.	Sheerness		+0 23	+3 4	+0 22	+ 9 51	0·1711	+ 0 52	0·0151
Aug. 24, 1847.	Portsmouth	Firequeen, 313	−0 5	+3 27	−0 21	+ 9 14	0·1605	− 7 47	−0·1354
Nov. 8, 1852.	Portsmouth		−0 3	+2 53	−0 37	+ 9 48	0·1702	− 5 47	−0·1008
June 5, 1858.	Portsmouth		+0 17	+2 14	+0 8	+ 4 49	0·0840	+ 0 51	0·0148
July 8, 1845.	Greenhithe	Fairy (*Yacht*), 312	+0 3	+1 58	−0 17	+ 3 55	0·0683	+ 1 3	0·0183
Mar. 22, 1849.	Portsmouth		+0 35	+2 8	+0 22	− 7 46	−0·1351	− 0 32	−0·0093
Feb. 19, 1850.	Portsmouth		+0 5	+1 50	+0 30	− 4 20	−0·0756	− 1 16	−0·0221
			+0 35	+3 33	+0 31	+13 25	0·2320	− 1 15	−0·0218
June 19, 1852.	Portsmouth		−0 33	+3 23	+0 6	+11 39	0·2019	− 0 33	−0·0096
Jan. 23, 1858.	Portsmouth		−0 20	+3 11	−0 22	+11 23	0·1974	+ 2 2	0·0355
June 5, 1854.	Greenhithe	Minx, 303	+0 15	+3 7	−0 6	− 1 54	−0·0331	− 2 20	−0·0407
Oct. 14, 1859.	Greenhithe	*	+1 37	+4 29	+0 15	− 4 48	−0·0837	− 4 11	−0·0729
1846.	Greenhithe	Onyx, 297	−0 18	+3 42	−0 24	− 7 54	−0·1374	− 4 16	−0·0744
1848.	Greenhithe		+0 25	+3 36	+0 25	− 5 30	−0·0958	− 3 53	−0·0677
1850.	Greenhithe	†	+0 39	+3 26	+0 27	+ 2 19	0·0404	− 8 23	−0·1458
Dec. 20, 1844.	Greenhithe	Princess Alice, 270	+0 21	+3 1	+0 10	+14 54	0·2571	+ 0 24	0·0070
Dec. 26, 1850.	Greenhithe		−0 7	+2 55	0 0	+12 59	0·2247	− 0 19	−0 0055
April 15, 1855.	Sheerness		+2 3	+3 36	−0 13	+12 1	0·2082	− 2 35	−0·0451
July 26, 1856.	Greenhithe		−0 12	+2 32	+0 16	+10 5	0·1751	− 1 47	−0·0311
May 18, 1859.	Greenhithe	Bann, 267	−2 15	+4 15	−0 39	+15 6	0·2605	+14 46	0·2549

* Fitted with iron tanks nearly the entire length of the vessel, for the purpose of carrying water.

† After a thorough repair, new boilers and funnel, and Standard compass placed 6 inches further forward.

TABLE I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Resultant of B and C, or ship's Total force.		Magnetic elements.		Position of standard compass.			Beams.	Horse-power and engines.	Where built.	Date of launching.
Direction.	Amount.	Horizontal force.	Dip, and nat. tang.	From funnel.	From tafrail.	Height from deck.				
				ft. in.	ft. in.	ft. in.				
352°	0·214 0·260	1·217	+63° 0' 1·96	42 2	16 8	7 0	Iron.	150, Paddle.	Glasgow (R. Napier).	28th October, 1844.
344	0·266	1·000	+68 40 2·56	42 2	16 8	7 0				
328½	0·316	1·000	+68 25 2·53	41 0	15 0	5 5				
339	0·262	1·000	+68 25 2·53	41 0	15 0	5 5				
18	0·129	1·000	+68 25 2·53	43 0	14 0	5 3	Wood, on quarter-deck.	200, Paddle.	Blackwall (Ditchburn and Mare).	March, 1845.
6	0·152	1·000	+68 25 2·53	43 0	14 0	4 10				
352	0·110 0·166	1·510	+52 0 1·28	43 0	14 0	4 10				
353	0·196	1·000	+68 25 2·53	43 0	14 0	4 10				
351	0·236	1·000	+68 40 2·56	41 9	15 1	5 0	Iron.	150, Paddle.	Glasgow (R. Napier).	28th November, 1844.
3	0·188	1·000	+68 40 2·56	41 9	15 1	5 0				
5	0·172	1·000	+68 40 2·56	41 9	15 1	5 0				
320	0·210	1·000	+68 30 2·54	55 0	31 9			120, Paddle.		Purchased July 1847.
329½	0·197	1·000	+68 30 2·54	55 0	31 9					
10	0·085	1·000	+68 30 2·54	62 9	25 0	3 7				
15	0·070	1·000	+68 30 2·54		unknown.		Wood.	120, Screw.	Blackwall (Ditchburn and Mare).	March, 1845.
184	0·135	1·000	+68 30 2·54	52 0	15 0	2 9¼				
196	0·079	1·000	+68 30 2·54	48 10	15 2	2 9				
355	0·233	1·000	+68 30 2·54	26 0	39 0	2 8				
357	0·202	1·000	+68 30 2·54	26 0	39 0	2 8				
10	0·201	1·000	+68 30 2·54	26 0	39 0	2 8				
231	0·052	1·000	+68 30 2·54	18 0	18 0	5 0		100, Screw.	Blackwall (Wigram).	5th September, 1846.
221	0·111	1·000	+68 30 2·54	36 0	9 6	3 6				
209	0·157	1·000	+68 30 2·54	23 0				120, Paddle.	Blackwall (Ditchburn and Mare).	November. 1845,
215	0·117	1·000	+68 30 2·54	23 0						
285	0·151	1·000	+68 30 2·54	22 6						
2	0·257	1·000	+68 30 2·54	22 0	35 6	5 10	Wood.	120, Paddle.	Blackwall.	1843.
358	0·225	1·000	+68 30 2·54	22 0	35 6	5 10				
348	0·213	1·000	+68 30 2·54	22 0	35 6	5 10				
350	0·178	1·000	+68 30 2·54	26 5	34 0	5 10				
44½	0·364	1·000	+68 30 2·54	49 0	29 0	4 7	Iron.	80, Paddle.	Millwall (J. S. Russell).	5th July, 1856.

Table I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients. A.	Permanent coefficients. D.	Permanent coefficients. E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.
May 25, 1857.	Sheerness	Brune, 267	−0° 35′	+6° 22′	+0° 56′	− 9° 15′	−0·1607	+ 3° 28′	0·0605
Aug. 7, 1849.	*Penetanguishine, Lake Huron, Canada.*	Mohawk, 228	−1 28	+3 1	−1 47	+10 15	0·1779	− 8 5	−0·1406
1846.	Greenhithe	Torch, 343	−0 26	+2 56	+0 5	+11 8	0·1931	− 4 3	−0·0706
May 10, 1852.	Greenhithe		−0 4	+2 43	+0 24	+10 41	0·1854	− 0 46	−0·0134
July 6, 1852.	*Madeira*		+3 2	+2 52	−0 5	+ 6 25	0·1117	− 1 20	−0·0233
			+2 48	+2 10	−0 43	+ 6 52	0·1196	− 0 57	−0·0166
July 22, 1852.	*St. Vincent, Cape de Verd Islands.*		−1 40	+2 46	−0 52	+ 7 4	0·1230	− 1 10	−0·0204
Sept. 29, 1852.	*Rio de Janeiro*		−0 7	+2 29	+0 9	+ 7 17	0·1268	− 1 6	−0·0192
Nov. 16, 1852.	*Tristan d'Acunha*		+0 12	+2 23	−0 56	+ 7 42	0·1340	− 3 13	−0·0561
Dec. 10, 1852.	*Cape of Good Hope*		−1 17	+1 57	+0 6	+ 9 18	0·1616	+ 0 30	0·0087
Jan. 26, 1853.	*St. Paul's Island, Indian Ocean.*		+1 58	+1 39	+0 6	+10 17	0·1785	− 0 28	−0·0081
Feb. 18, 1853.	*Swan River, Australia*		−1 5	+1 31	−0 15	+ 6 58	0·1213	− 0 13	−0·0038
Mar. 15, 1853.	*King George's Sound*		−2 8	+2 44	+0 44	+ 8 41	0·1510	− 1 13	−0·0212
July 1856.	*East Coast, Australia*		+0 25	+1 37	−0 11	+ 8 18	0·1443	+ 0 23	0·0067
May 11, 1844.	Woolwich	Dover, 224	+1 14	+2 38	+0 8	− 6 57	−0·1210	− 4 10	−0·0727
Sept. 25, 1849.	Plymouth		+0 2	+2 23	−0 18	− 4 58	−0·0866	+ 0 25	0·0073
June 23, 1843.	Greenhithe	Wilberforce, 457	+0 33	+2 18	+0 15	− 7 48	−0·1357	− 7 15	−0·1262
July 5, 1843.	*River Gambia*		0 0	+2 6	+0 7	− 4 39	−0·0811	− 4 12	−0·0732
Jan. 13, 1844.	Greenhithe	Dwarf, 164	−0 35	+2 2	+0 17	+13 5	0·2264	− 3 8	−0·0547

Table II.—Floating Batteries*, Her Majesty's Navy.

July 1857.	Sheerness	Terror, 1971	−1 45	+6 17	−0 44	+25 12	0·4258	+2 3	0·0358
July 5, 1855.	Greenhithe	Meteor	−1 19	+0 12	0 0	− 1 19	−0·0230	−3 31	−0·0613
Mar. 31, 1856.	Sheerness	Thunder, 1469	+0 34	−0 40	+0 9	−11 33	−0·2002	−1 33	−0·0270
Mar. 26, 1856.	Sheerness	Trusty, 1539	+0 4	+1 37	−1 54	−16 55	−0·2910	+3 52	0·0674

* Of these, Terror is the only *Iron-built* vessel; the others are *Wood-built* plated with iron.

TABLE I.—Iron-built Ships, Her Majesty's Navy (*continued*).

Resultant of B and C, or ship's Total force.		Magnetic elements.		Position of standard compass.			Beams.	Horse-power and engines.	Where built.	Date of launching.
Direction.	Amount.	Horizontal force.	Dip, and nat. tang.	From funnel.	From tafrail.	Height from deck.				
°			° ′	ft. in.	ft. in.	ft. in.				
159½	0·171	1·000	+68 30 2·54	45 3	28 8	4 4	Iron.	80, Paddle.	Millwall (J. S. Russell).	30th August, 1856.
321	0·227	0·876	+76 0 4·01	10 0				60, Paddle.	Limehouse (Fairbairn and Co.).	Kingston, Upper Canada. 21st Feb. 1843†.
340	0·206	1·000	+68 40 2·56	42 0	16 0	6 0	Iron.	150, Paddle.	Blackwall (Ditchburn and Mare).	February, 1845.
356	0·186	1·000	+68 40 2·56	42 0	16 0	5 7				
348	0·114 0·153	1·339	+60 40 1·78	42 0	16 0	5 7				
352	0·120 0·161	1·339	+60 40 1·78	42 0	16 0	5 7				
350½	0·125 0·198	1·585	+46 0 1·04	42 0	16 0	5 7				
351½	0·128 0·219	1·709	−11 21 −0·20	42 0	16 0	5 7				
337	0·146 0·189	1·295	−43 0 −0·93	42 0	16 0	5 7				
3	0·162 0·190	1·174	−54 42 −1·41	42 0	16 0	5 7				
357	0·179 0·198	1·106	−68 0 −2·48	42 0	16 0	5 7				
358	0·122 0·182	1·490	−62 30 −1·92	42 0	16 0	5 7				
352	0·152 0·214	1·406	−65 0 −2·14	42 0	16 0	5 7				
3	0·145 0·246	1·7 approx.		42 0	16 0	5 7				
211	0·141	1·000	+68 40 2·05		unknown.		Iron.	100, Paddle.	Liverpool (Laird).	1840.
175	0·087	1·000								
223	0·185	1·000	+68 40 2·56	unknown.		7 0	Iron.	100, Paddle.	Liverpool.	1841.
222	0·109 0·193	1·771	+38 30 0·79							
346	0·233	1·000	+68 40 2·56	32 9	unknown.		Wood.	90	Blackwall.	1842.

TABLE II.—Floating Batteries, Her Majesty's Navy (*continued*).

5	0·426	1·000	+68 25 2·53	70 0	37 0	5 5	Iron.	Screw.	Newcastle-on-Tyne (Palmer).	26th April, 1856.
249	0·065	1·000	+68 25 2·53	79 0	16 6	4 8	Wood.	Screw.		
188	0·202	1·000	+68 25 2·53	83 0	10 10	4 7	Wood.	Screw.		
167	0·299	1·000	+68 25 2·53	84 0	9 10	4 6	Wood.	Screw.		

† Delivered in parts at Woolwich, November 1841.

TABLE III.—Screw Steam-vessels, Her Majesty's Navy (Wood-built).

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients. A.	Permanent coefficients. D.	Permanent coefficients. E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.
April 29, 1859.	Portsmouth	MERSEY, 3739......	+0° 52′	−0° 15′	−0° 5′	+7° 44′	0·1346
Jan. 5, 1860.	Sheerness	ARIADNE, 3202......	+0 8	+0 31	−0 12	+8 37	0·1498
Mar. 29, 1859.	Plymouth	DORIS, 2479......	+1 11	−0 30	+0 43	+7 11	0·1250
Jan. 7, 1856.	Plymouth	SANSPAREIL, 2334......	+0 4	+0 58	−0 13	+23 43	0·4022
May 22, 1857.	*Cape of Good Hope*	....	−0 37	+1 16	+0 36	+3 41	0·0642
1857.	*Canton*	....	+0 8	+0 53	−0 7	+7 41	0·1337
Oct. 20, 1859.	Portsmouth	ARROGANT, 1872......	−0 32	+0 20	+0 10	+6 21	0·1106
Sept. 5, 1859.	Sheerness	CLIO, 1470......	−0 43	+0 56	+0 4	+9 39	0·1676
June 1, 1859.	Sheerness	CADMUS, 1462......	−0 23	−0 20	−0 4	+11 1	0·1911
June 7, 1856.	Portsmouth	PYLADES, 1278......	+1 22	+0 27	−1 6	+12 48	0·2215
Sept. 9, 1856.	*Sydney, C. Breton Island*	....	−0 6	0 0	−0 12	+17 47	0·3054
Sept. 26, 1856.	Portsmouth	HIGHFLYER, 1161......	+0 52	+0 36	+0 13	+11 42	0·2028
Dec. 12, 1856.	*Rio de Janeiro*	....	+1 4	−0 42	+0 7	+4 49	0·0840
Feb. 1857.	*Cape of Good Hope*	....	−0 50	−0 23	−0 8	+4 20	0·0755
May 26, 1857.	*Hong Kong*	....	+0 7	−0 32	+0 10	+3 21	0·0584
Dec. 2, 1857.	*Canton River*	....	+0 15	+0 6	+0 10	+3 45	0·0654
May 17, 1858.	*Shanghae*	....	−0 3	−0 5	+0 39	+6 25	0·1118
May 23, 1859.	Portsmouth	FALCON, 992......	+0 15	+0 10	−0 25	+6 37	0·1152
1859.	Plymouth	ENCOUNTER, 953......	+0 29	+0 27	−0 3	+7 1	0·1222
Nov. 28, 1859.	Greenhithe	MUTINE, 875......	+0 12	−0 19	−0 10	+8 35	0·1492
Nov. 19, 1859.	Sheerness	FAWN, 748......	+0 16	+0 42	−0 40	+7 21	0·1279
May 21, 1857.	Plymouth	CORDELIA, 579......	+0 19	−0 40	−0 5	+7 57	0·1383
Aug. 8, 1857.	*Cape of Good Hope*	....	+1 5	+0 20	−0 22	−1 12	−0·0209
Sept. 20, 1858.	*Apia, Upolu, Pacific Ocean*	....	−0 27	+0 40	+1 10	+1 24	0·0244
Mar. 7, 1857.	Portsmouth	PLUMPER, 490......	+0 14	+0 52	+0 5	+6 1	0·1048
April 1857.	*Lisbon*	....	+0 4	−0 10	−0 18	+4 39	0·0811
May 1857.	*Rio de Janeiro*	....	−0 49	+0 47	+0 14	+2 8	0·0372
Sept. 1, 1857.	*Valparaiso*	....	+0 6	+0 37	+0 37	+1 6	0·0192
Oct. 1857.	*Sandwich Islands*	....	−0 49	+0 26	+0 5	+2 17	0·0398
Jan. 30, 1858.	*Vancouver I., Esquimalt*	....	−0 13	+0 23	−0 3	+5 45	0·1002
June 17, 1859.	*Vancouver I., Nanaimo*	....	+0 52	+0 5	+0 5	+6 26	0·1120
Jan. 1, 1856.	Greenhithe	TICKLER (Gun-boat), 232	−1 37	+1 26	−0 13	+0 15	0·0043

Table III.—Screw Steam-vessels, Her Majesty's Navy (Wood-built) (*continued*).

Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.	Resultant of B and C, or ship's Total force. Direction.	Resultant of B and C, or ship's Total force. Amount.	Magnetic elements. Horizontal force.	Magnetic elements. Dip, and nat. tang.	Position of standard compass. From funnel.	Position of standard compass. Height from deck.	Horse-power of engines.
						ft. in.	ft. in.	
+1° 23′	0·0241	10°	0·137	1·000	+68° 15′	121 0	7 10	1000
−2 26	−0·0424	344	0·156	1·000	+68 15	119 0	6 3	800
−1 15	−0·0218	350	0·127	1·000	+68 15	110 0	6 11	800
+1 45	0·0305	4½	0·404	1·000	+68 15 2·50	19 4	On poop.	400
+2 8	0·0372	30	0·074	1·174	−54 42 − 1·41	19 4		
+0 57	0·0166	7	0·135	2·049	+31 30 0·61	19 4		
−0 28	−0·0081	356	0·111	1·000	+68 15 2·50	68 0	6 7	360
+4 46	0·0831	26½	0·187	1·000	+68 15 2·50	80 0	7 6	400
+2 35	0·0451	13	0·196	1·000	+68 15 2·50	87 0	6 6	400
+4 23	0·0764	19	0·234	1·000	+68 15 2·50			350
+5 22	0·0935	17	0·320	0·772	+76 30 4·17			
+0 48	0·0140	4	0·203	1·000	+68 15 2·50	70 0	6 0	250
+0 8	0·0023	2	0·084	1·708	−11 21 − 0·20	70 0	6 0	
−1 18	−0·0227	343	0·079	1·174	−54 42 − 1·41	70 0	6 0	
+0 29	0·0084	8	0·059	2·049	+31 26 0·61	70 0	6 0	
+0 9	0·0026	2	0·065	2·049	+32 35 0·63	70 0	6 0	
+0 20	0·0058	3	0·112	1·813	+45 18 1·01	70 0	6 0	
−2 39	−0·0462	338	0·124	1·000	+68 15 2·50	71 0	7 0	100
+0 10	0·0029	1	0·122	1·000	+68 15 2·50	73 0	5 5	360
−2 50	−0·0494	342	0·157	1·000	−68 15 2·50	70 0	6 6	200
−1 55	−0·0334	345½	0·132	1·000	+68 15 2·50	71 0	6 7	100
−0 27	−0·0078	357	0·139	1·000	+68 15 2·50	64 0	6 5	150
+1 40	0·0291	126	0·036	1·174	−54 42 − 1·41	64 0	6 5	
−0 26	−0·0076	343	0·025	2·083	−35 30 − 0·72	64 0	6 5	
+1 13	0·0212	11	0·107	1·000	+68 15 2·50	38 7	5 6	60
+1 8	0·0198	13	0·083	1·216	+61 5 1·81	38 7	5 6	
+0 32	0·0093	14	0·038	1·709	−11 21 − 0·20	38 7	5 6	
+0 3	0·0008	2	0·019	1·887	−35 37 − 0·72	38 7	5 6	
+0 20	0·0058	8	0·040	1·628	−42 00 − 1·11	38 7	5 6	
+0 55	0·0160	9	0·102	1·040	+71 55 3·06	38 7	5 6	
+0 29	0·0084	5	0·112	1·016	+72 25 3·15	38 7	5 6	
−0 57	−0·0166	285	0·017	1·000	+68 15 2·50	35 0	3 7	60 high pressure

Table IV.—Paddle-wheel Steam-vessels, Her Majesty's Navy (Wood-built).

Date.	Place of observation.	Ship's name and Tonnage.	Permanent coefficients. A.	Permanent coefficients. D.	Permanent coefficients. E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.	Resultant of B and C, or ship's Total force. Direction.	Resultant of B and C, or ship's Total force. Amount.	Magnetic elements. Horizontal force.	Magnetic elements. Dip, and nat. tang.	Position of standard compass. From funnel.	Position of standard compass. Height from deck.	Horse-power of engines.
May 27, 1846.	Greenhithe ...	Terrible, 1847.	−0° 12′	+0° 55′	+0° 8′	+5° 05′	0·0886	+0° 10′	0·0029	2°	0·089	1·000	69° 0′ 2·60	ft. in. 33 9	ft. in.	800
Dec. 26, 1845.	Sheerness	Retribution, 1641.	−0 48	+1 22	+0 7	+10 21	0·1797	+4 20	0·0755	23	0·195	1·000	+69 0 2·60	57 6	7 9	400
Oct. 8, 1856.	Sheerness	....	−1 7	+0 30	+0 20	+9 33	0·1659	+4 27	0·0776	25	0·183	1·000	+69 0 2·60			
Aug. 17, 1857.	*Callao*	....	−0 5	+0 13	+0 3	+2 59	0·0520	+0 49	0·0142	15	0·054	1·963	−7 0 −0·12			
Mar. 1859.	*Hong Kong* ...	....	+0 18	+0 12	−0 1	+4 29	0·0782	+1 16	0·0221	16	0·081	2·049	+31 26 0·61			
Sept. 1843.	....	Penelope, 1616.	+0 17	+1 25	+0 21	+7 24	0·1288	+0 18	0·0052	2	0·129	1·000	69 0 2·60	35 0		
May 29, 1857.	Sheerness	Cyclops, 1106.	−0 15	+2 10	−0 1	+6 51	0·1193	−1 9	−0·0201	350	0·121	1·000	+68 30 2·53	38 6	4 3	320
Aug. 17, 1857.	*St. John's, Newfoundland.*	....	+0 28	+1 34	+0 36	+9 31	0·1653	−1 1	−0·0177	354	0·166	0·776	+76 0 4·01	38 6	4 3	
Dec. 1859.	*Kurrachee* ...	....	+0 16	+1 17	+0 24	+2 26	0·0424	−0 10	−0·0029	356	0·042	2·012	+28 15 0·54	38 6	4 3	
Sept. 5, 1848.	Portsmouth ...	Sphynx, 1056.	+0 15	+1 50	−0 18	+8 58	0·1558	+0 23	0·0067	2	0·156	1·000	+69 0 2·60	32 3	......	500
1851.	*Hong Kong* ...	....	−0 46	+0 35	−0 33	+2 34	0·0448	−0 12	−0·0035	356	0·045	2·049	+31 26 0·61	32 3		
1847.	Sheerness	Geyser, 1054.	+0 2	+1 14	−0 4	+9 12	0·1599	−2 3	−0·0358	347	0·164	1·000	+69 0 2·60	33 0	......	280
1850.	*C. of Good Hope*	....	−0 46	+0 59	+0 11	−2 12	−0·0384	−0 56	−0·0163	203	0·042	1·174	−54 42 −1·41			
Oct. 17, 1857.	Plymouth	Styx, 1057	+1 30	+1 37	+0 3	+5 33	0·0967	0 0	0·0000	360	0·097	1·000	+68 30 2·53	36 10	5 7	280
July 1859.	*Halifax, N.S.* ...	....	−1 27	+1 40	+0 8	+8 18	0·1443	+0 35	0·0102	4	0·145	0·823	+75 30 3·87			
1847.	Greenhithe ...	Acheron, 720.	+0 23	+0 58	+0 3	+7 43	0·1343	+2 23	0·0416	17	0·141	1·000	+68 40 2·56	30 0	5 0	170
1850.	*Port Nicholson, New Zealand.*	....	+0 54	−0 33	−0 16	+1 26	0·0250	−1 47	−0·0311	309	0·040	1·382	−65 0 −2·14			

TABLE V.—Steam-Ship *Great Eastern* (Iron-built).

Date.	Place of observation.	Vessel's name and Tonnage.	Permanent coefficients. A.	D.	E.	Coefficient B.	Ship's force to Head. Earth's horizontal force =1·000.	Coefficient C.	Ship's force to Starboard. Earth's horizontal force =1·000.	Resultant of B and C, or ship's Total force. Direction.	Amount.	Position of compass.
					By Admiralty Standard Compass.							
Sept. 7, 1859.	River Thames...	GREAT EASTERN, 22,000	−0° 10′	+4° 21′	−0° 37′	+23° 13′	0·3942	+25° 38′	0·4326	47°	0·585	Height from deck ...... ft. 4 in. 11
Sept. 10, 12, 1859.	Portland	....	−1 3	+4 44	−0 45	+22 42	0·3859	+16 43	0·2876	37	0·480	From rudder head 41 0
Oct. 22, 24, 1859.	Holyhead	....	−0 24	+4 8	−0 17	+19 18	0·3305	+12 3	0·2088	32	0·390	" spindle of capstan 17 6; " nearest funnel ... 165 0
					Mast Compass, 45 feet from deck.							
Sept. 7, 1859.	River Thames...	....	+0 4	+1 32	+0 4	+12 43	0·2201	+11 12	0·1942	41	0·295	For relative positions, see Plate XV.
Sept. 10, 12, 1859.	Portland	....	+1 21	+1 30	−0 10	+16 12	0·2790	+ 4 20	0·0756	15	0·290	
Oct. 22, 24, 1859.	Holyhead	....	+2 20	+1 0	+0 7	+17 2	0·2929	+ 7 30	0·1305	24	0·320	
					Platform Compass.							
Sept. 7, 1859.	River Thames...	....	−1 40	+7 55	−0 12	+13 34	0·2346	+22 41	0·3856	59	0·455	
Sept. 10, 12, 1859.	Portland	....	+0 43	+5 19	+0 40	+10 17	0·1785	+21 5	0·3597	64	0·405	
					Foremost Bridge Compass.							
Sept. 7, 1859.	River Thames...	....	+0 3	+4 31	−0 9	+31 55	0·5287	+17 47	0·3054	30	0·610	

Supplement.

[*Added during the printing of the paper.*]

In June 1860, prior to the departure of the steam-ship Great Eastern on her first Atlantic voyage, I was enabled, through the attention and cooperation of the captain, John V. Hall, and managing director, T. Bold, Esq., to institute further experiments on the changes of the ship's magnetism, under the same conditions as those already recorded as having been made in the River Thames, at Portland, and at Holyhead, in September and October 1859.

Subsequent to the observations made at Holyhead, the Great Eastern rode out a violent gale in that harbour,—remarkable as causing the total wreck of the ship Royal Charter in the immediate neighbourhood,—which necessarily subjected many parts of the hull to severe concussion from the strain on the cables: the ship's services were then confined to the passage to Southampton; and during the sojourn at that port for the following seven months, she quietly swung round the moorings to the tides and variable winds. Extensive artificers' works were latterly performed in the internal equipments.

These details are worthy of notice, from the striking progressive diminution of the ship's magnetic force, and further tendency to the fore-and-aft direction of the neutral points of disturbance which the Southampton observations developed.

The same Admiralty standard compass having been placed in the exact position of former experiments, the correct magnetic bearing of the extreme point of the Isle of Wight, visible from the anchorage (distant 12 miles), was determined from a series of astronomical bearings and the known magnetic variation of the place, the necessary correction for parallax due to the length of the ship being allowed for the successive points of the compass as the ship swung round.

From the wind prevailing in one direction for several days prior to the departure of the Great Eastern, I was only able, although engaged on the 13th, 14th, and 15th of June, to obtain the deviations on sixteen and a half consecutive points; namely, from S.S.E., by the South, to N.N.W. $\frac{1}{2}$ W.: these deviations, resulting from a curve drawn through fifty-one separate determinations, made under highly favourable circumstances, were as follows:—

Ship's head by Stand: comp:	Deviation.	Head by Stand: comp:	Deviation:	Head by Stand: comp:	Deviation.
S.S.E. . .	° ′ 2 0 E.	S.W. . . .	° ′ 6 30 W.	W.N.W. . .	° ′ 14 50 W.
S. by E. . .	0 20 E.	S.W. by W. .	8 25 W.	N.W. by W.	14 15 W.
South . . .	1 40 W.	W.S.W. . .	10 15 W.	N.W. . . .	12 50 W.
S. by W. . .	3 40 W.	W. by S. . .	12 0 W.	N.W. by N.	10 10 W.
S.S.W. . .	4 45 W.	West . . .	13 0 W.	N.N.W. ½ W.	8 0 W.
S.W. by S. .	5 30 W.	W. by N. . .	14 20 W.		

It was necessary to deduce from these results the probable values for the remaining points of the compass; this appeared to be obtained with sufficient accuracy by trials of the coefficients B, C, D, with various assumed values, adopting those, the deviations resulting from which should approximate most closely to the actual observed deviations on the sixteen and a half determined points. The coefficients A and E were, under the circumstances, assumed as 0° 0′.

The resulting values for B of $+13° 30′$, C$+1° 40′$, D$+4° 20′$, afforded a satisfactory approximation; from whence the ship's force in direction and amount are respectively 7° and 0·235, the earth's horizontal magnetic force being considered, as at the other ports, 1·000.

A recapitulation of the Great Eastern's total magnetic force at each place of observation is herewith appended, as also a Table of deviations, which brings practically to view the change in the deviation of the mariners compass in a newly launched iron vessel, amounting in this special case to a decrease of 12° on some points of the compass in the first five days, 19° in seven weeks, and nearly three points, or 32° 10′ in the first nine months of service afloat.

	Angle of force from ship's head.	Total force.	Earth's horizontal force.
1859. September 7, River Thames . .	° 47	0·585	1·000
„ „ 10—12, Portland . . .	37	0·480	„
„ Oct. 22—24, Holyhead . . .	32	0·390	„
1860. June 13—15, Southampton . .	7	0·235	„

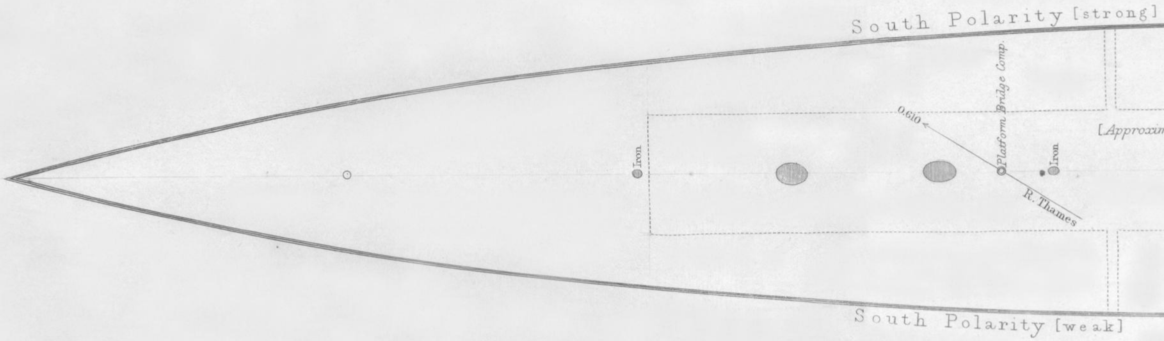
Deviations

Deviations of the Compass observed on board the steam-ship *Great Eastern*, 1859–60; in a position on the upper deck, in the middle line of the ship; distant 46 feet 4 inches from the after or jigger mast; 17 feet 6 inches before the spindle of the after capstan, and 41 feet 0 inches before the rudder head; the needle elevated 4 feet 11 inches from the deck.

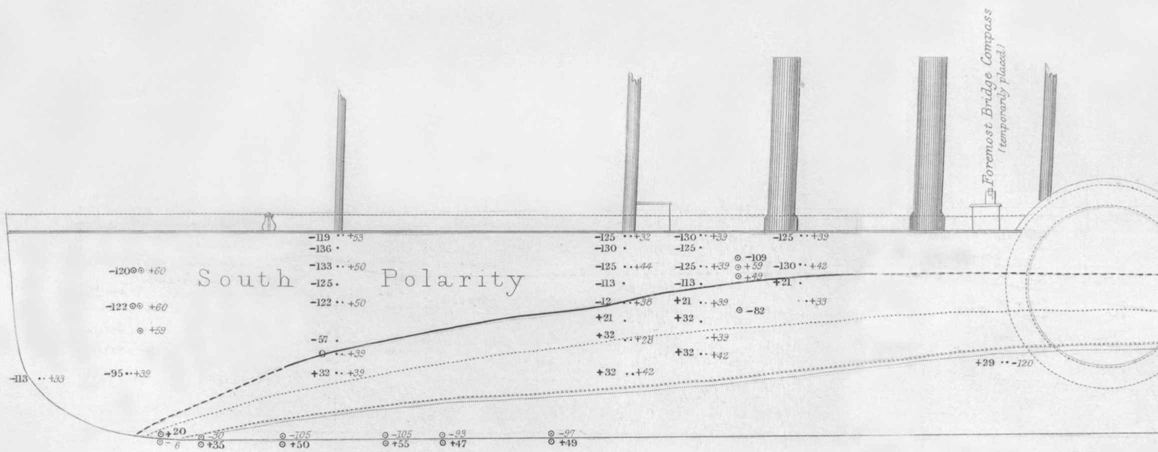
Ship's head, *correct* magnetic.	River Thames, 7th September, 1859.	Portland, 10th to 12th Sept. 1859.	Holyhead, 22 to 24th October, 1859.	Southampton, 13th, 14th, 15th June, 1860.
	° ′	° ′	° ′	° ′
North.	15 50 E.	9 20 E.	7 0 E.	1 15 E.
N. by E.	21 0 „	14 40 „	10 50 „	4 30 „
N.N.E.	25 0 „	19 25 „	14 50 „	7 25 „
N.E. by N.	29 0 „	23 0 „	18 10 „	10 0 „
N.E.	32 0 „	26 30 „	21 20 „	12 40 „
N.E. by E.	36 0 „	29 20 „	24 0 „	14 50 „
E.N.E.	38 10 „	31 0 „	25 30 „	16 10 „
E. by N.	39 0 „	31 15 „	26 0 „	16 50 „
East.	38 0 „	30 10 „	25 0 „	16 0 „
E. by S.	32 30 „	26 0 „	22 0 „	14 0 „
E.S.E.	22 0 „	20 20 „	17 0 „	11 30 „
S.E. by E.	6 0 „	12 0 „	9 20 „	8 30 „
S.E.	10 30 W.	0 0 „	1 15 „	5 30 „
S.E. by S.	23 40 „	11 00 W.	5 40 W.	3 0 „
S.S.E.	29 30 „	17 40 „	10 50 „	2 40 „
S. by E.	31 20 „	21 30 „	14 20 „	0 20 „
South.	31 30 „	23 0 „	16 30 „	2 0 W.
S. by W.	30 50 „	23 45 „	17 40 „	4 0 „
S.S.W.	29 30 „	23 50 „	18 15 „	5 10 „
S.W. by S.	27 30 „	23 50 „	18 40 „	6 0 „
S.W.	25 30 „	23 10 „	18 50 „	8 0 „
S.W. by W.	23 40 „	22 40 „	19 0 „	10 0 „
W.S.W.	21 30 „	21 45 „	18 40 „	11 50 „
W. by S.	19 0 „	20 30 „	18 0 „	13 30 „
West.	16 0 „	18 45 „	17 0 „	14 30 „
W. by N.	13 20 „	16 30 „	15 30 „	14 40 „
W.N.W.	10 0 „	13 40 „	13 10 „	14 0 „
N.W. by W.	6 40 „	10 50 „	10 20 „	12 30 „
N.W.	3 0 „	8 0 „	7 0 „	10 30 „
N.W. by N.	1 10 E.	4 35 „	3 40 „	7 45 „
N.N.W	5 40 „	0 20 „	0 0 „	5 0 „
N. by W.	10 30 „	4 10 E.	3 30 E.	2 0 „

IRON

GREAT



Sketch *shewing the Magnetic character of the topsides, the positions of the several Com*



Sketch of the S. S. Great Eastern, shewing the external ne

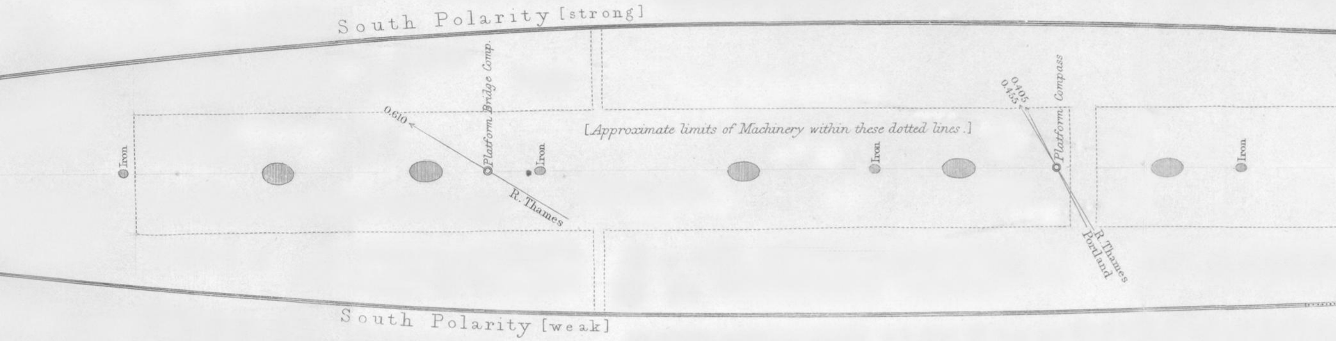
Note. *The broad continuous, and non-continuous lines,_Septembe*
The small dotted lines, are approximately in November 1857

{Dark lines and figures; Port side of the Ship.
{Light ditto ; Starboard

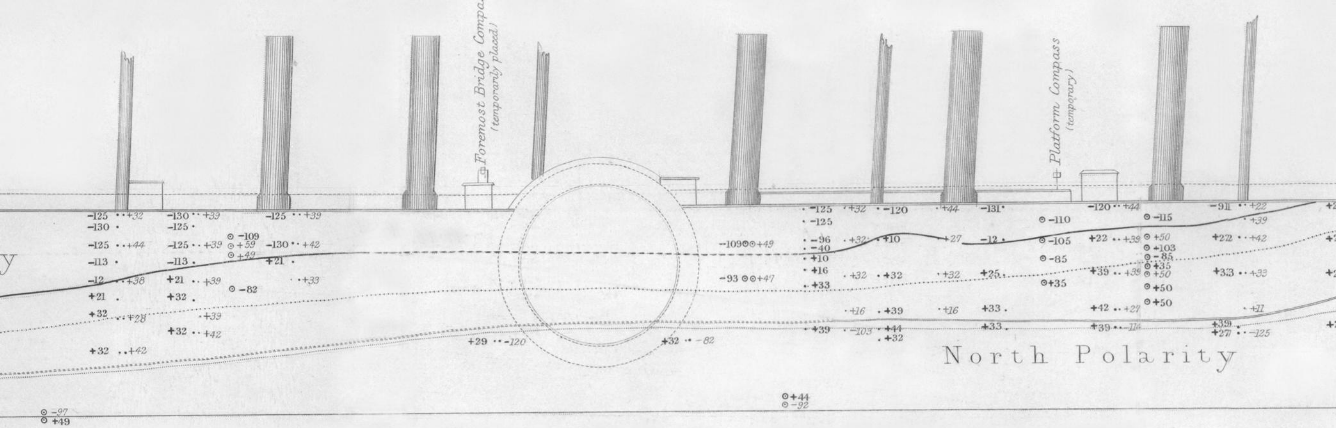
Deviation of the Compass *(in degrees)* {*The observations with a dot, (which denotes the position),*
{ „ „ *encircled*

IRON STEAM SHIP

GREAT EASTERN.



...wing the Magnetic character of the topsides, the positions of the several Compasses employed, and the direction and amount of Ships Force. (The arrows denoting



Sketch of the S. S. Great Eastern, shewing the external neutral Magnetic Lines, or, the separation between the North & South polarit...

Note. *The broad continuous, and non-continuous lines, September 1–5, 1859, at Deptford.*
The small dotted lines, are approximately in November 1857, prior to launching.

{Dark lines and figures; Port side of the Ship.
{Light ...... ditto ......, Starboard ......

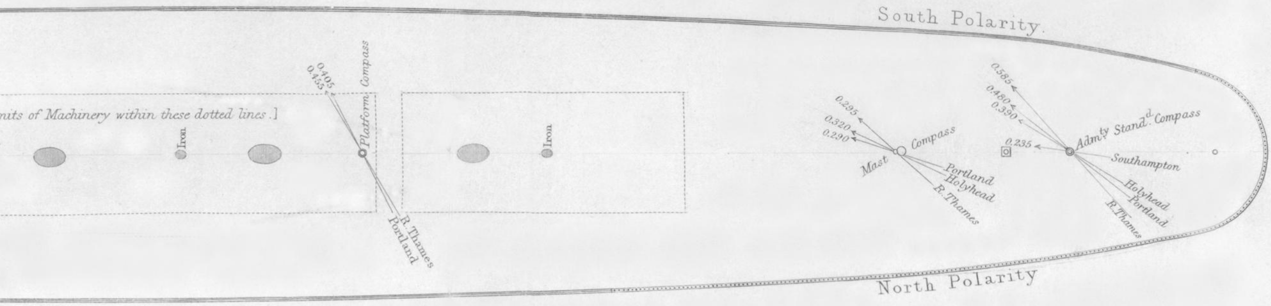
...n of the Compass *(in degrees)* {*The observations with a dot, (which denotes the position), are those made in 1859* / ......" ......" ...... *encircled* ......" ...... *1857*} *+ East Deviation, − West Deviation*

10 20 30 40 50

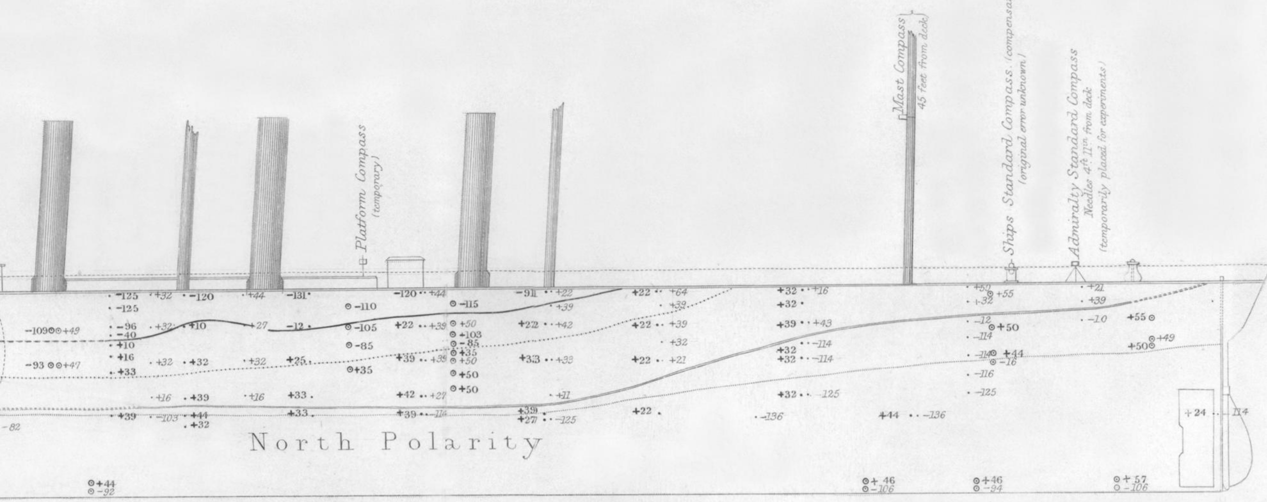
Direction

TEAM SHIP

EASTERN.



es employed, and the direction and amount of Ships Force. *(The arrows denoting Ships force are proportionally drawn to scale)*



l Magnetic Lines, or, the separation between the North & South polarity of the Hull.

1859, at Deptford.

r to launching.

10 20 30 40 50 100 150 200

Scale of feet

ose made in 1859 } *+ East Deviation, − West Deviation*

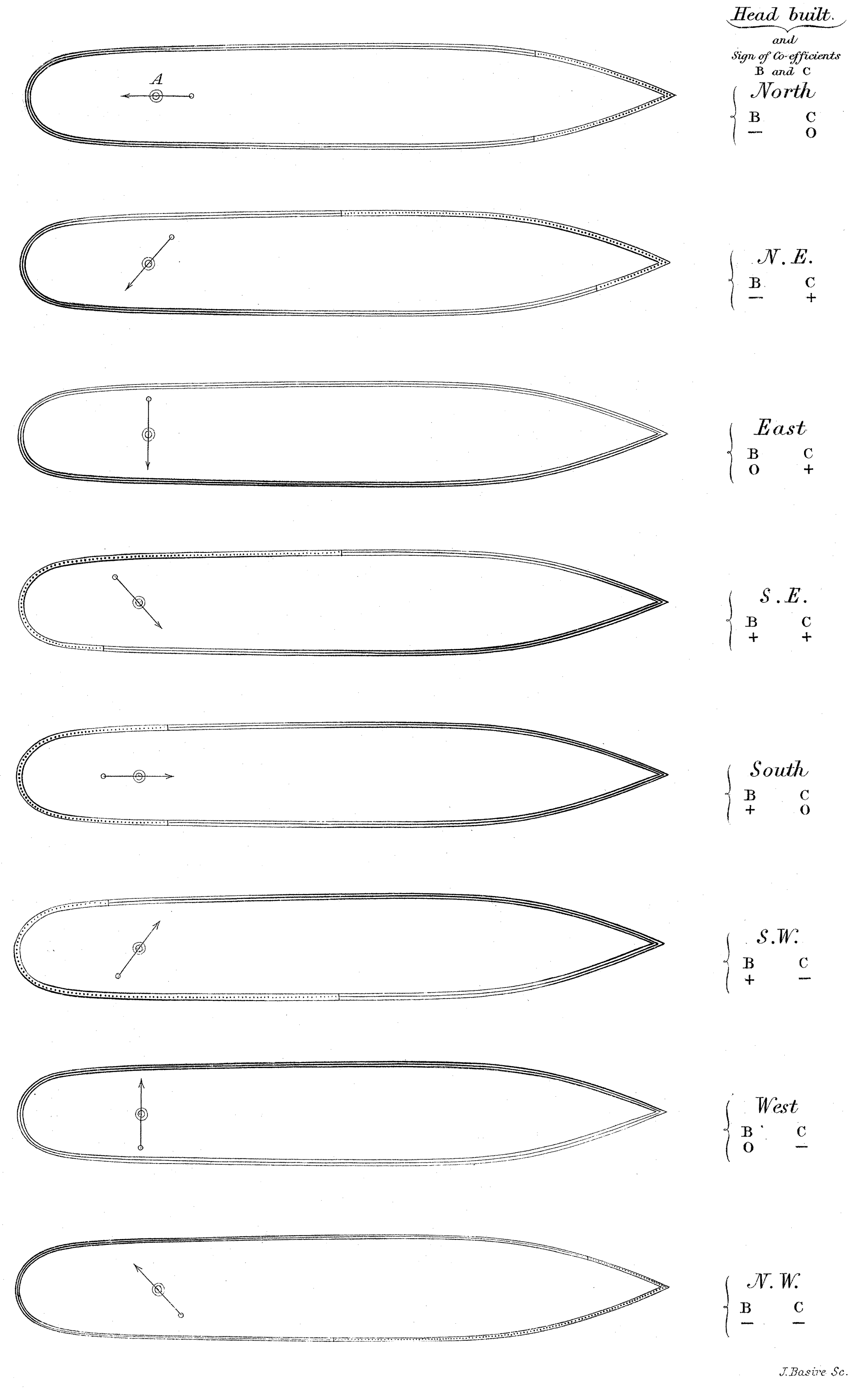
1857

Direction of Keel and Head while building S. 29°. 50′. E. Magtc.

at Deptford S. 46°. 0′. E.

J. Basire Sc.

Diagrams shewing Polarity of the topsides of an Iron vessel according to the direction in which her Head may be built with reference to the Magnetic meridian.



Note. indicates South polarity (attracting north end of needle) ; ——— North ——— (repelling north end of needle) — The intensity of the shading a corresponding intensity of Magnetism.

A, is the general position of the Standard Compass in Ships.

The Arrow indicates the direction of the Ships force.

J. Basire Sc.